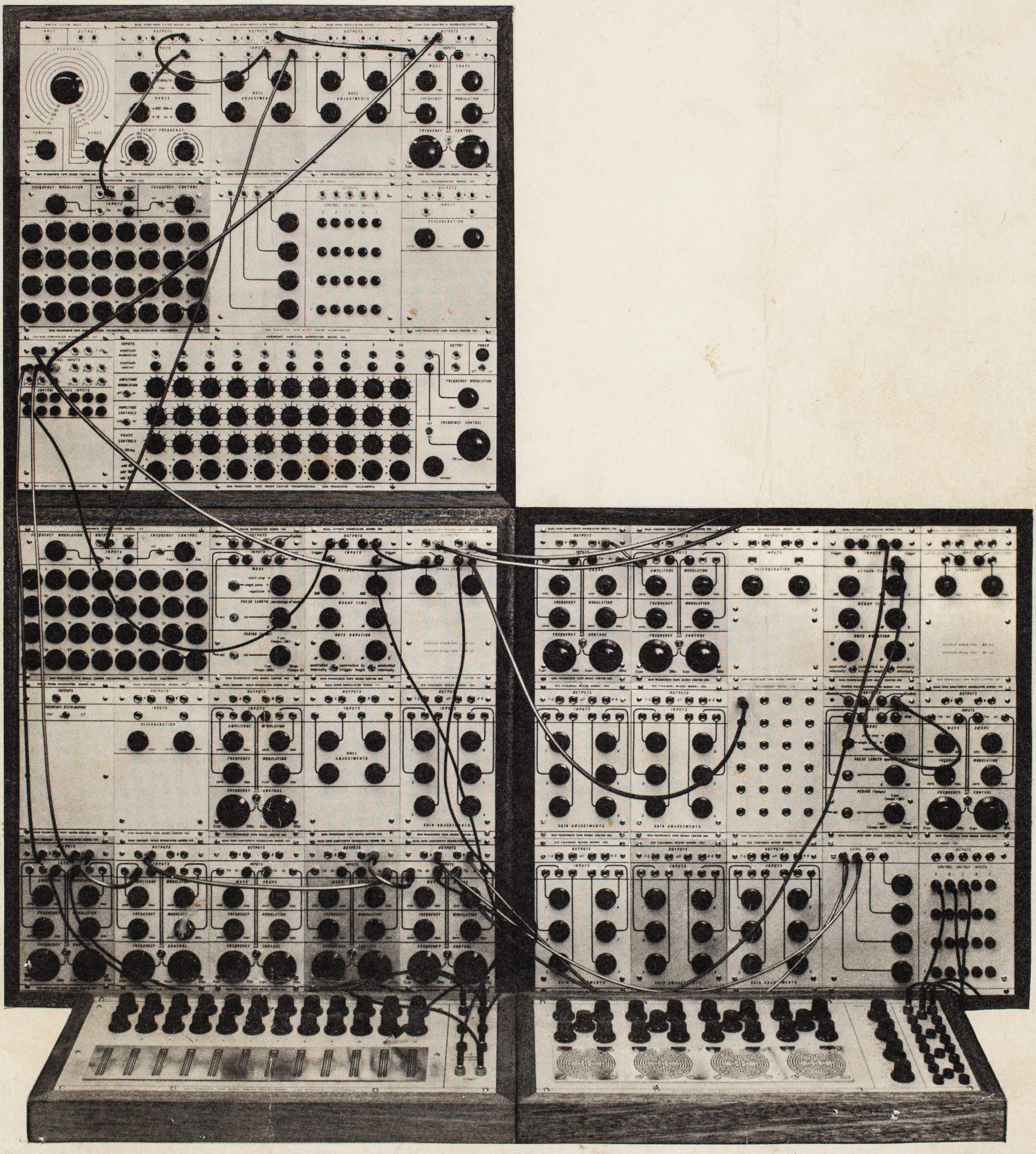
THE MODULAR ELECTRONIC MUSIC SYSTEM



SOME HISTORY

In the past decade electronic music has developed into a form that assumes all the roles of music in our culture, from concert pieces to film music and rock-and-roll. Studios specializing in electronically generated music have been built in Europe and America and, while still few in number, have exerted considerable impact on the cultural activity of our time. An increasing number of composers are active in the field, and within a few years electronic music may well be part of the curriculum at every college and university music department.

The offspring of a technology which is itself but half a century old, electronic music is in its infancy. Instruments specifically designed for its production have been crude and generally unavailable. The San Francisco Tape Music Center approached the instrumentation problem in the traditional manner: ingenious application of surplus equipment that saw service in World War II bombers; occasional acquisition of new (and expensive) instruments designed for the physics laboratory; construction of innumerable pieces of electronic gadgetry from circuits provided by trade publications, hobby manuals, and friendly engineers.

As the number of member-composers grew, the limitations of the Tape Music Center's facilities became increasingly apparent. Maintenance and overhead costs were high, studio time was wasted in setup and tape splicing, and instruction in the intricacies of impedance matching and ground loops was necessary.

Last year the Tape Music Center received Rockefeller Foundation support which enabled the Center to initiate the development of a line of improved studio equipment. Basic objectives were:

1) The achievement of direct, immediate control of musical parameters. Instruments should be played in real time, eliminating such note-forming routines as: set frequency—start recorder—stop recorder—measure—cut—splice—repeat, etc.

2) Compatability of all equipment. Rules for interconnecting equipment to be straight-forward and consistent. Interfacing with external equipment (recorders, tuners, microphones, etc.) should be readily accomplished.

3) Fully transistorized circuitry, employing conservative design and high quality components. Reliable operation with minimal maintenance must be realized.

4) A special requirement of the Tape Center was that the equipment be lightweight and portable, thus making feasible its use in the composer's home, the concert hall, and on tour.

5) Without compromising other design objectives, cost should be low. Power supplies and cabinetry should be common to several units, and modular construction should be employed to permit economical system expansion.

Equipment that meets the above criteria has been designed and installed in the Center's studio. Results have exceeded all expectations. The new instrumentation can accommodate twice as many member-composers, and the time required to put a composition on tape has been reduced substantially. The range of sounds and formats far exceeds that previously available. The instrument has been played on stage in several concerts in the Bay Area. (Live, on-line, real-time performance of electronic music without tape buffering is, to our knowledge, unprecedented.)

THE MODULAR ELECTRONIC MUSIC SYSTEM

Now offered for sale by the
SAN FRANCISCO TAPE MUSIC CENTER

An exciting new instrument for generating and processing electronic material.

An imaginatively flexible studio instrument capable of producing an enormous range of sounds and formats.

Direct immediate control of musical parameters enabling live real-time performance of electronic music without tape buffering.

Copyright 1966 by Buchla Associates

Comment

"The instrument is the answer for composers who wish to work with electronic materials but care nothing for electronics, and teachers will find it student-proof."

Robert Erickson,
Composer
Teacher, San Francisco
Conservatory of Music

"Aside from creating an imaginatively flexible studio instrument, Mr. Buchla has made it practical for a composer to have a complete electronic music studio in his own home."

Mort Subotnick,
Composer

". . . a keyboard connected to an enormous range of the sounds of our time. Every composer should come to see, hear, and possibly play the thing, just to know what resources Buchla has made available."

Lou Gotlieb,
San Francisco Chronicle

"It could be the precursor of fascinating developments in the field of electronic music."

Carl Cunningham,
San Francisco Chronicle

"A most remarkable instrument for manipulating sound. As useful in the concert hall as it is in the studio."

David Tudor,
Musician

THE SYSTEM

The Modular Electronic Music system that was developed at the Tape Music Center is composed of functional *modules*, each designed to generate a particular class of signals or perform a specific type of signal processing. Each module is 7 inches high and 4¼ inches (or an integral multiple thereof) wide. Up to 15 modules sharing a single power supply may be assembled in a single cabinet, and form a *super-module*.

The system employs three varieties of signals, each with a distinctly different function:

Audio signals, the raw material of electronic music, are formed by various sorts of generators (sine, square, sawtooth, harmonic) or are produced externally (tape loop, radio, microphone). In constructing a piece, they may be filtered, gated, mixed, modulated, or otherwise processed. The patch cords carrying audio signals within the system are grey, shielded cables terminated with miniature phone plugs. A standard level of Odb (ref. 600Ω) is employed for audio signals within the system.

Control voltages, used to determine frequencies, envelope characteristics, amplitudes and other parameters, are generated by keyboards, programmable voltage sources, and format generators. Black banana plug patch cords are used to interconnect control voltages. The standard control voltage range is from .5 to 15 volts.

Timing pulses are originated by keyboards, programmable sequencers, and pulse generators. They are used to trigger notes, open gates, or initiate chains of musical events. Timing pulses are about 10 volts in amplitude and are interconnected with red banana plug patch cords.

The rules for interconnection are straight-forward. Any number of inputs may be connected to a single output. Timing pulse outputs may be paralleled and connected to one input. The system output may be derived from any module; output is of sufficient magnitude to drive line inputs on tape recorders or sensitive inputs on power amplifiers.

AVAILABILITY

The Modular Electronic Music system described herein is now offered for sale through the Tape Music Center. Data and prices are available on request. Demonstrations and instruction can be arranged in many localities.

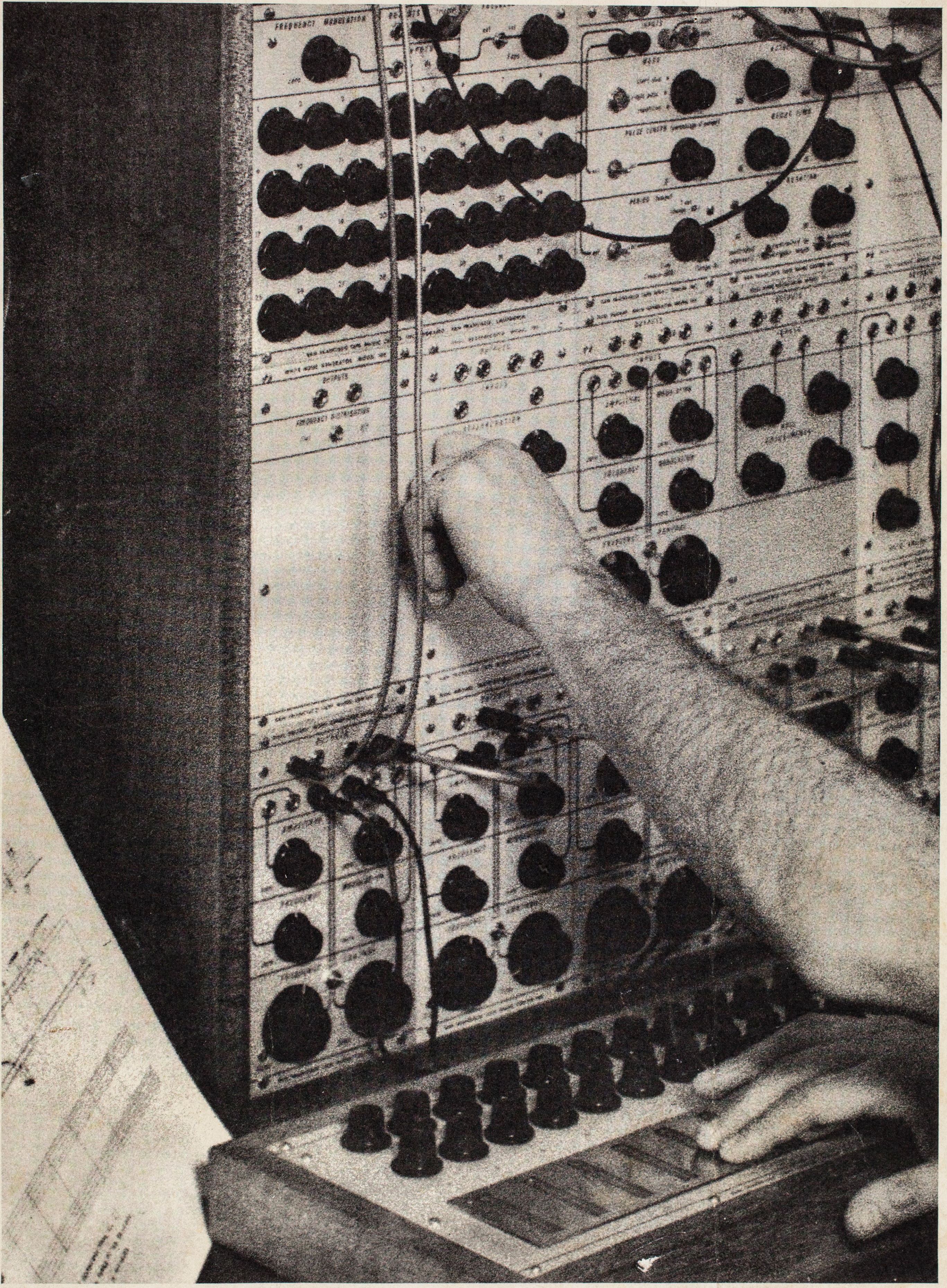
Delivery is approximately 60 days from receipt of order. Units are shipped air parcel post FOB San Francisco unless otherwise specified. Average shipping weight is 35 pounds per super-module.

Terms are 50% cash with order; 50% on delivery. Thirty days credit may be extended to rated institutions.

The system is guaranteed by the manufacturer, Buchla Associates, against defects in parts and workmanship. Guarantee extends for six months, unless equipment is modified or tampered with.

Address inquiries and orders to:

THE SAN FRANCISCO TAPE MUSIC CENTER
321 Divisadero Street, San Francisco, California 94117


FREQUENCY MODULATION

THE MODULAR ELECTRONIC MUSIC SYSTEM

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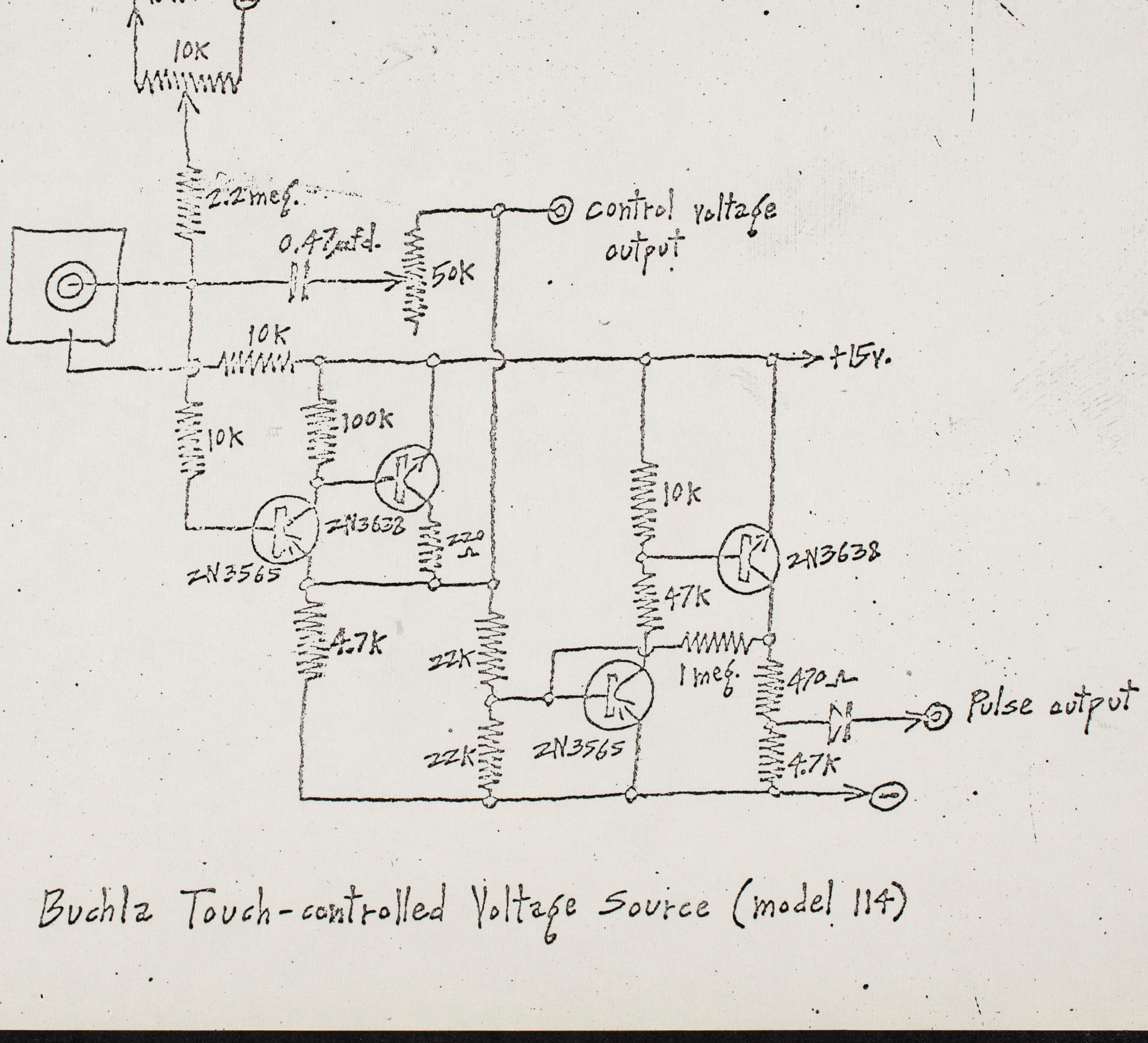
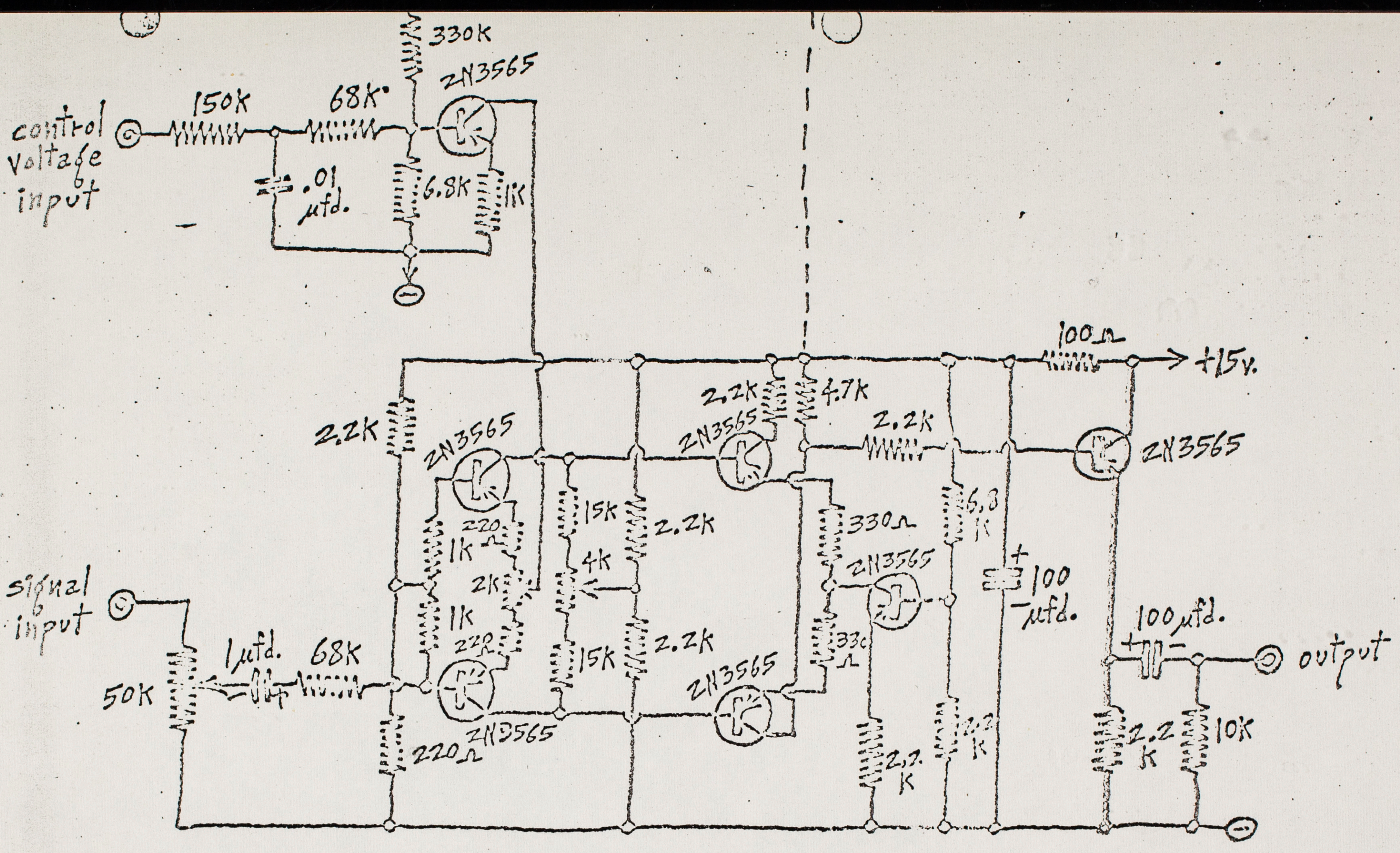
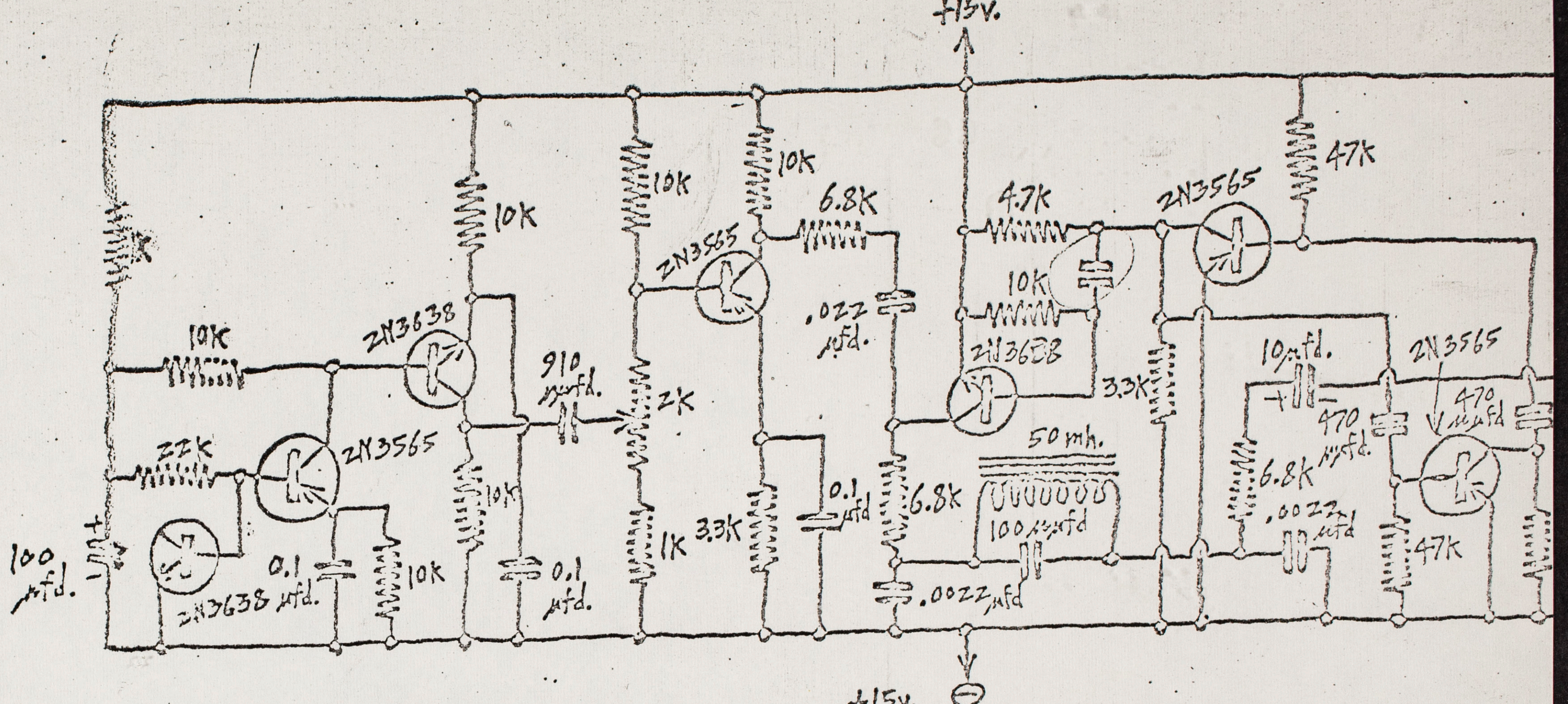
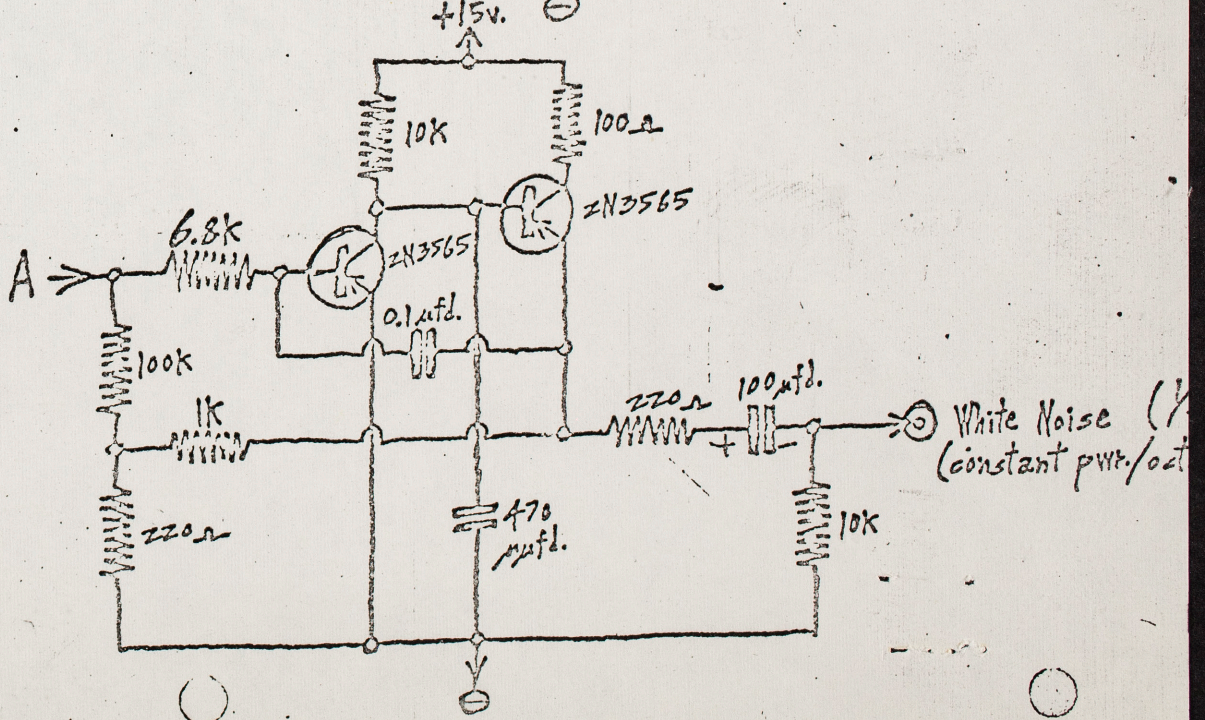

+15v.
10K
2.2meg.
0.47mfd.
50K
control voltage output
10K
+15v.
100K
10K
2N3638
2N3565
220Ω
10K
2N3638
47K
4.7K
22K
1meg.
470Ω
Pulse output
22K
2N3565
4.7K

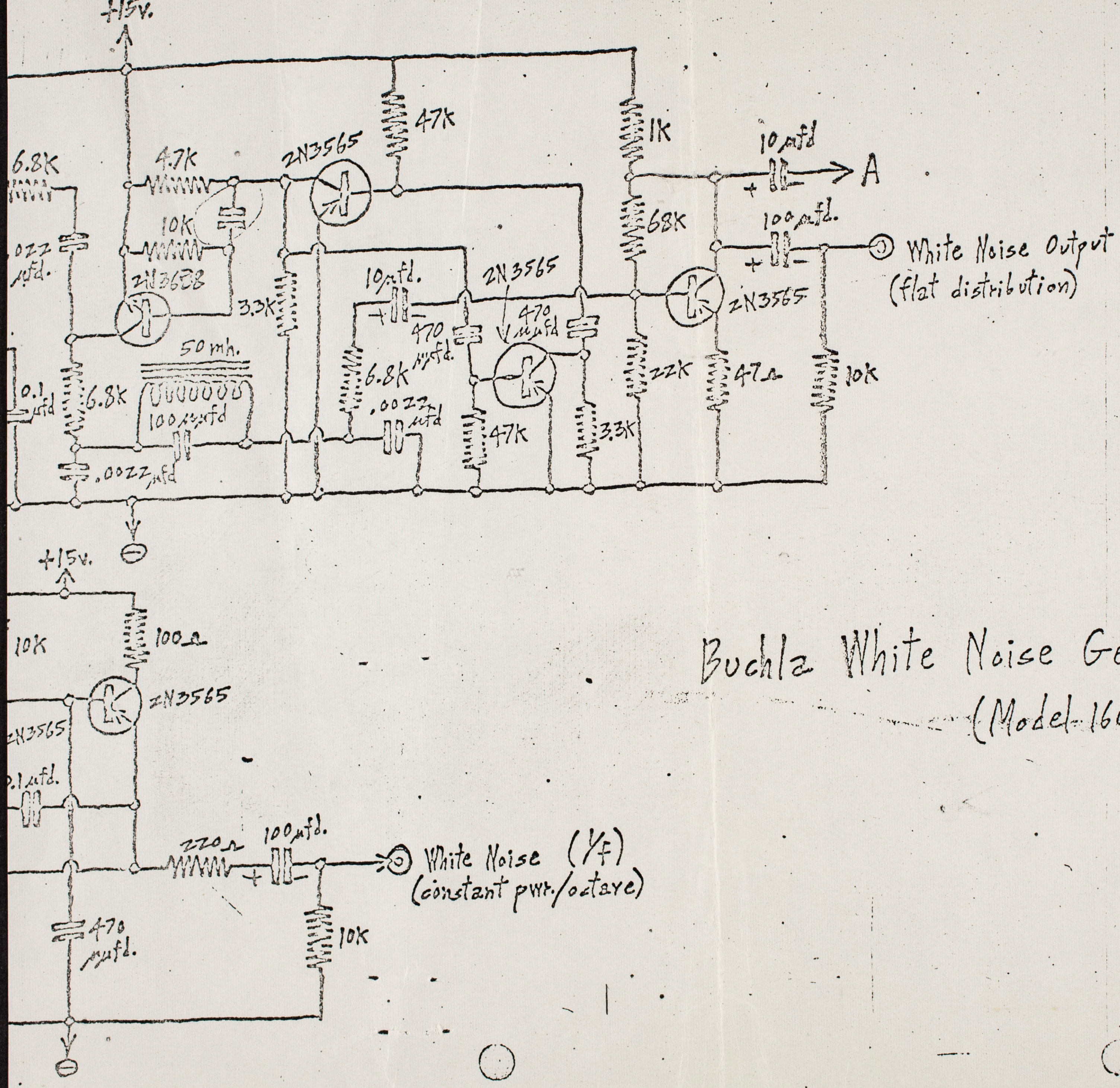
Buchla Touch-controlled Voltage Source (model 114)


control voltage input
150K
68K
330K
2N3565
.01 µfd.
6.8K
1K
100Ω
+15v.
2.2K
2N3565
2.2K
4.7K
2.2K
2N3565
15K
2.2K
220Ω
1K
4K
2K
1K
220
15K
2.2K
330Ω
2N3565
6.8 K
100 µfd.
signal input
50K
1µfd.
68K
2N3565
330Ω
100µfd.
output
2N3565
220Ω
2N3565
2.2 K
2.2 K
2.2 K
10K

$\frac{1}{2}$ Buchla Dual Voltage-controlled Gate (model 110)


+15v.
47K
10K
10K
10K
6.8K
4.7K
10K
10K
22K
ZN3638
ZN3565
ZN3565
ZN3565
2N3638
2N3565
910 µµfd.
2K
.022 µfd.
10 µfd.
470 µµfd
470 µµfd
3.3K
6.8K
6.8K
50 mh.
100 µµfd
+
100 µfd.
ZN3638
0.1 µfd.
10K
10K
0.1 µfd.
1K
3.3K
0.1 µfd
.0022 µfd
.0022 µfd
47K


+15v.
10K
100Ω
ZN3565
A
6.8K
ZN3565
0.1 µfd.
100K
1K
220Ω
100 µfd.
+
-
White Noise (1/
(constant pwr./oct
220Ω
470 µµfd.
10K

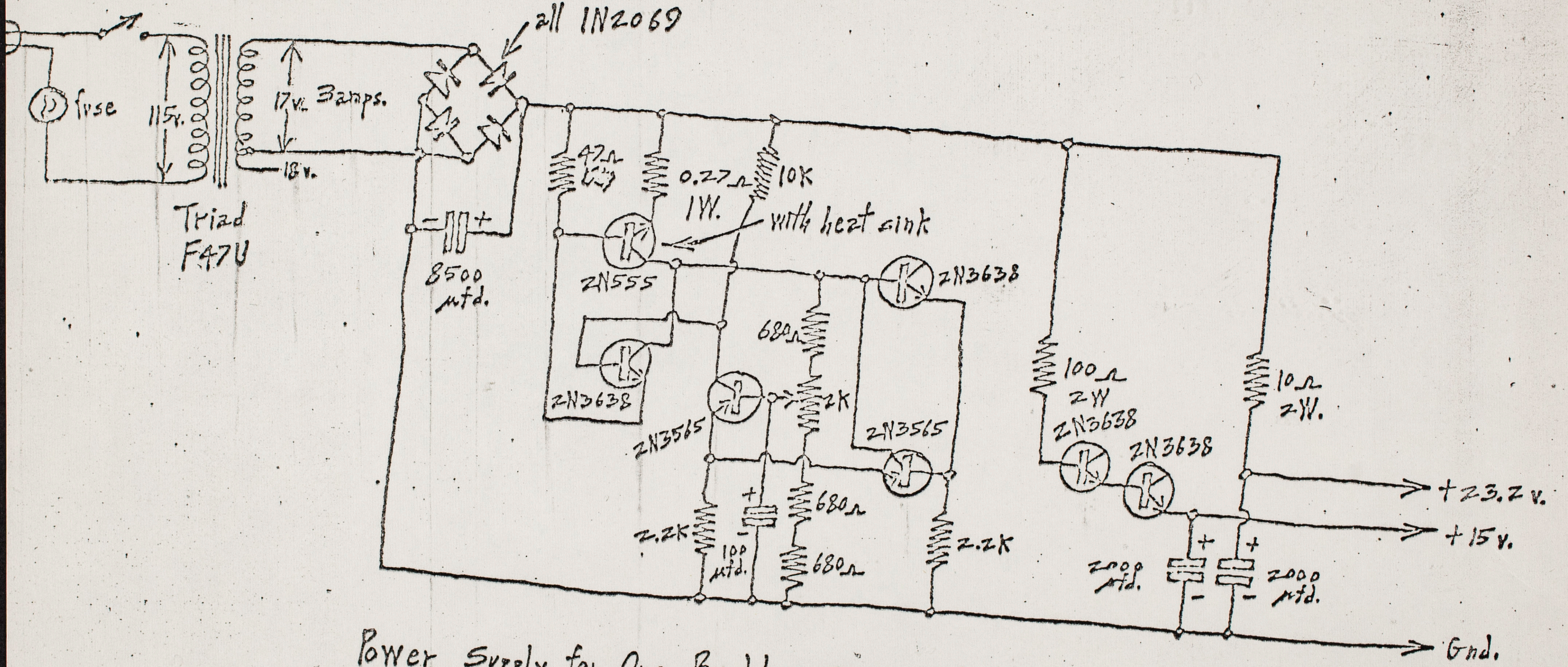


+15v.
6.8K
4.7K
47K
1K
10 μfd
A
2N3565
10K
.022 μfd.
100 μfd.
White Noise Output (flat distribution)
68K
2N3638
3.3K
10 μfd.
470 μμfd.
2N3565
470 μμfd
2N3565
50 mh.
0.1 μfd
6.8K
6.8K
100 μμfd
.0022 μfd
22K
47Ω
10K
47K
3.3K
.0022 μfd
+15v.
10K
100Ω
2N3565
2N3565
.1 μfd.
220Ω
100 μfd.
White Noise (1/f) (constant pwr./octave)
470 μμfd.
10K

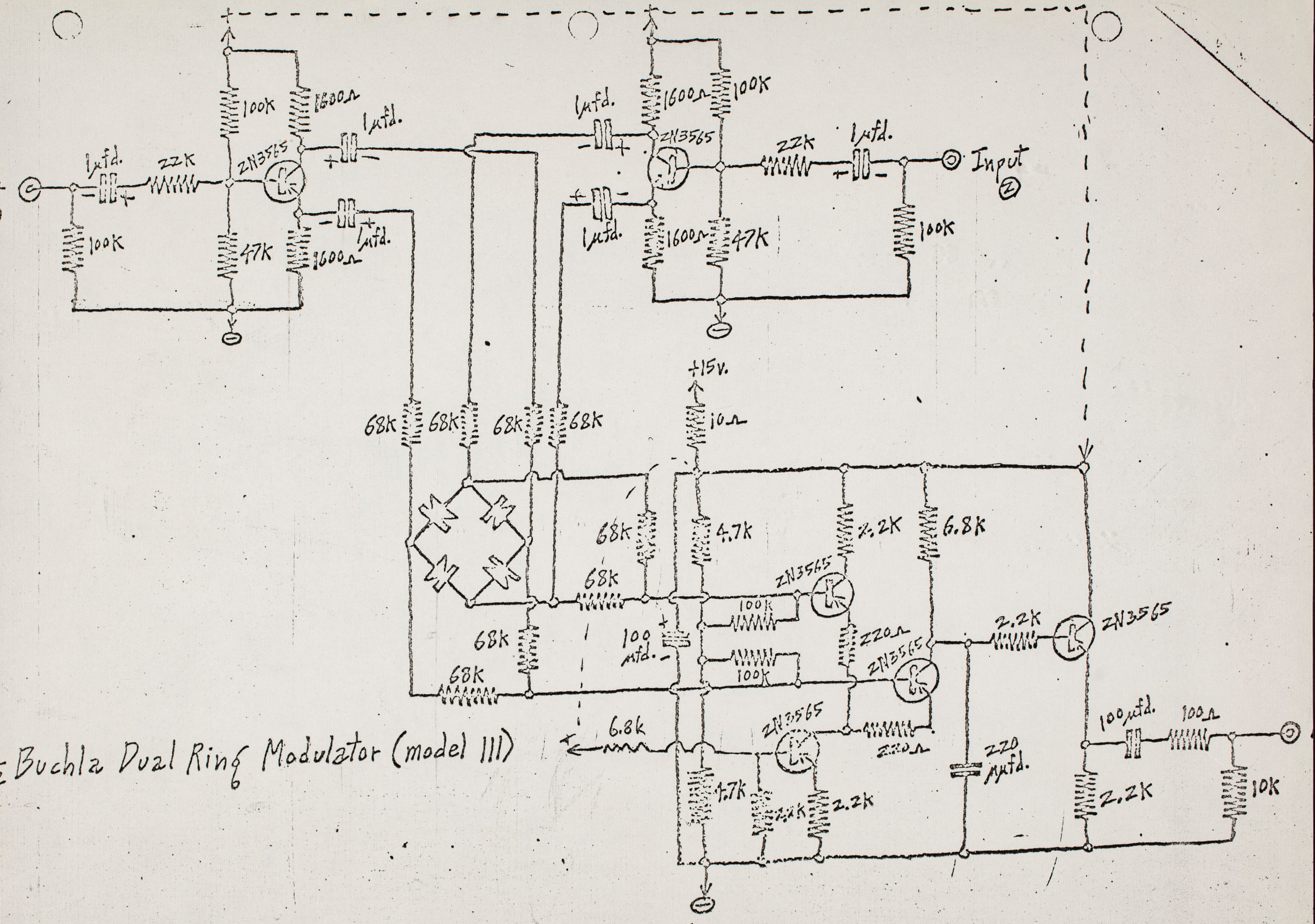
Buchla White Noise Generator

(Model 160)

Mills prototype 1N2071

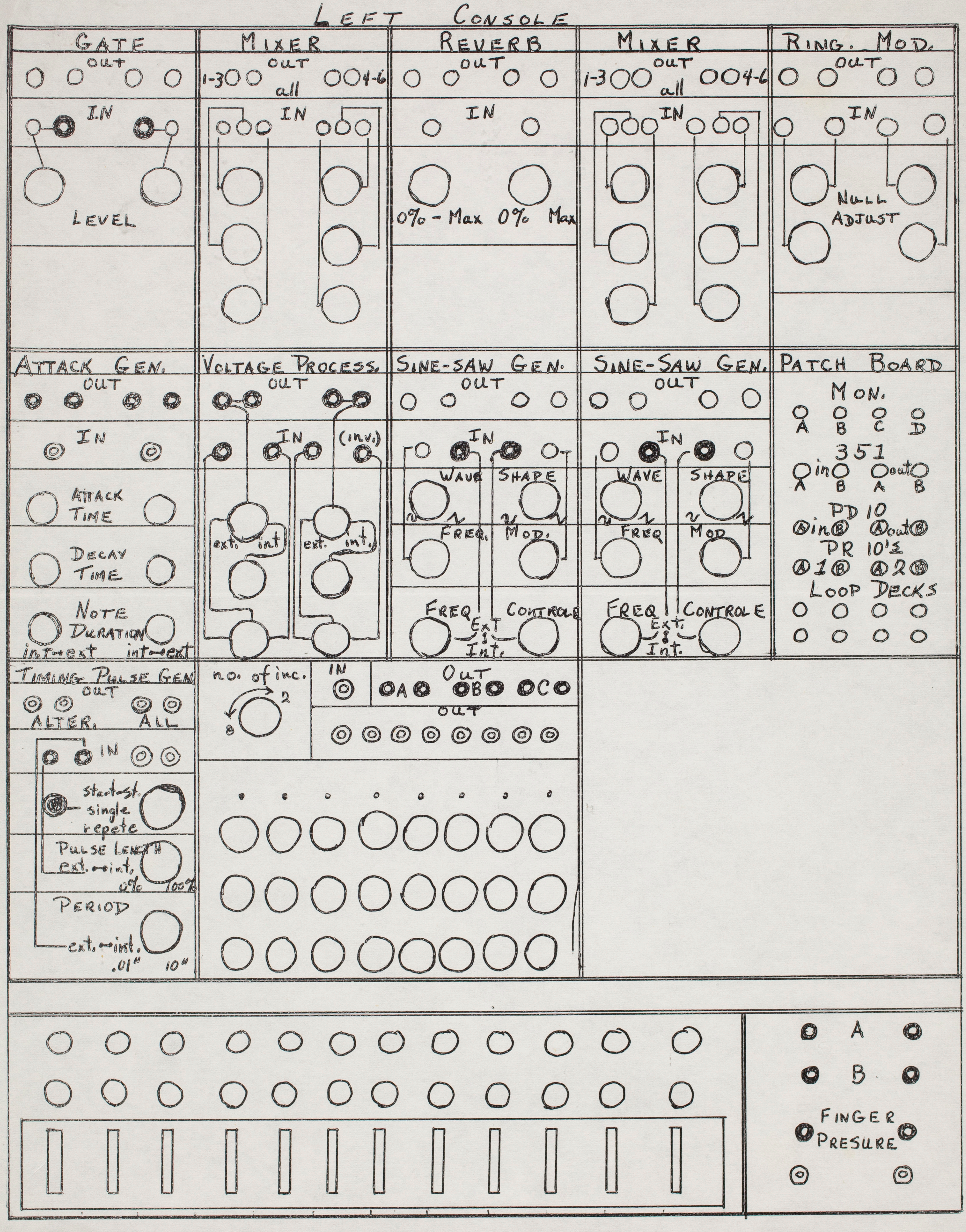

fuse
115v.
Triad
F47U
17v. 3amps.
18v.
all 1N2069
8500
mfd.
47Ω
0.27Ω
1W.
10K
with heat sink
2N555
2N3638
2N3638
680Ω
2K
2N3565
2N3565
2.2K
100
mfd.
680Ω
680Ω
2.2K
100Ω
2W
2N3638
2N3638
10Ω
2W.
+23.2v.
+15v.
2000
mfd.
2000
mfd.
Gnd.

Power Supply for One Buchla Super Module


1μfd.
22K
100K
1600Ω
47K
2N3565
1μfd.
1600Ω
100K
2N3565
22K
1μfd.
Input ②
100K
1600Ω
47K
+15v.
10Ω
68k
68k
68k
68k
68k
4.7k
2.2K
6.8k
68k
2N3565
100k
220Ω
100 μfd.
68k
68K
100k
2N3565
2.2K
2N3565
6.8k
2N3565
220Ω
220 μμfd.
100 μfd.
100Ω
4.7k
2.2k
2.2k
2.2K
10K

Buchla Dual Ring Modulator (model III)

LEFT CONSOLE


GATE
OUT
IN
LEVEL
MIXER
OUT
1-3
all
4-6
IN
REVERB
OUT
IN
0% - Max
0% Max
MIXER
OUT
1-3
all
4-6
IN
RING. MOD.
OUT
IN
NULL ADJUST
ATTACK GEN.
OUT
IN
ATTACK TIME
DECAY TIME
NOTE DURATION
int↔ext
int↔ext
VOLTAGE PROCESS.
OUT
IN
(inv.)
ext.
int.
ext.
int.
SINE-SAW GEN.
OUT
IN
WAVE SHAPE
FREQ. MOD.
FREQ CONTROLE
Ext.
Int.
SINE-SAW GEN.
OUT
IN
WAVE SHAPE
FREQ MOD
FREQ CONTROLE
Ext.
Int.
PATCH BOARD
MON.
A B C D
351
in
out
A B A B
PD 10
A in B
A out B
PR 10's
A 1 B
A 2 B
LOOP DECKS
TIMING PULSE GEN
OUT
ALTER.
ALL
IN
start-st.
single
repete
PULSE LENGTH
ext.↔int.
0%
100%
PERIOD
ext.↔int.
.01"
10"
no. of inc.
2
8
IN
Out
A
B
C
OUT
A
B
FINGER PRESURE

1:58

:31 4:5

B 56" Swinger

A 9"

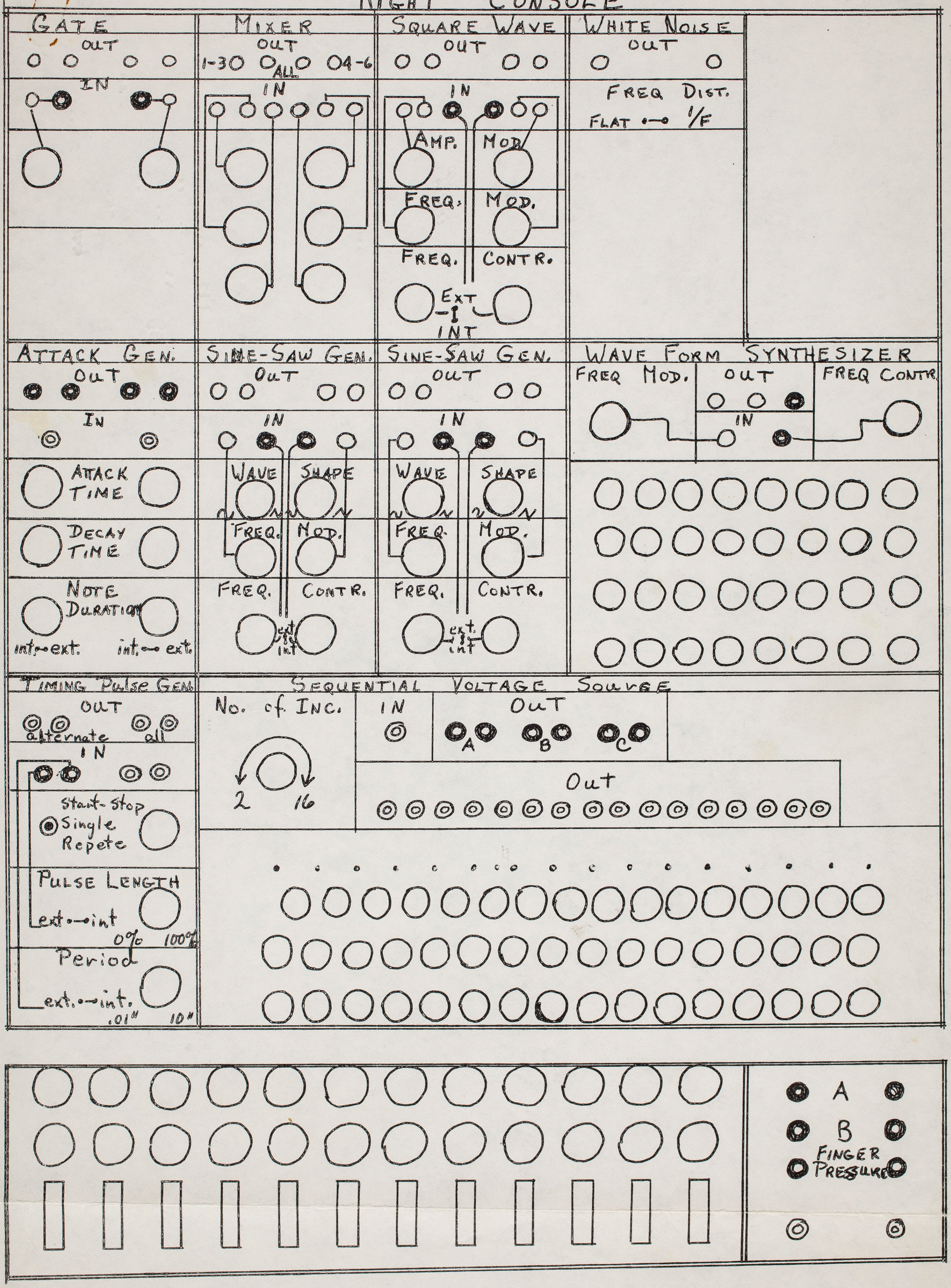
1'3"

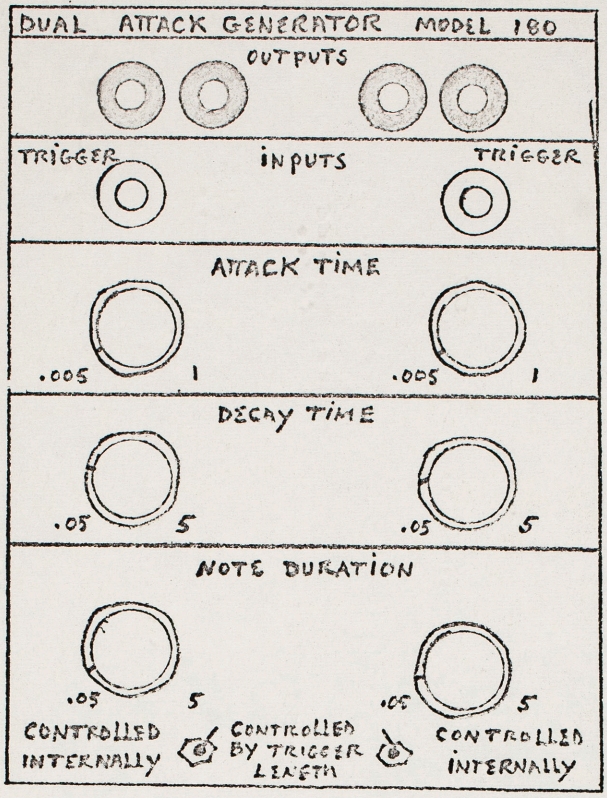
45

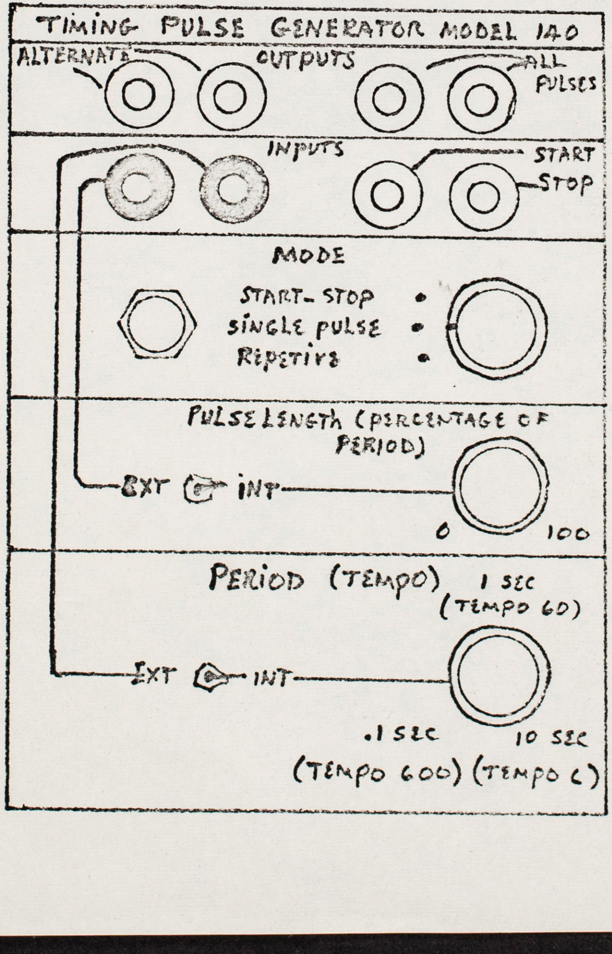
25

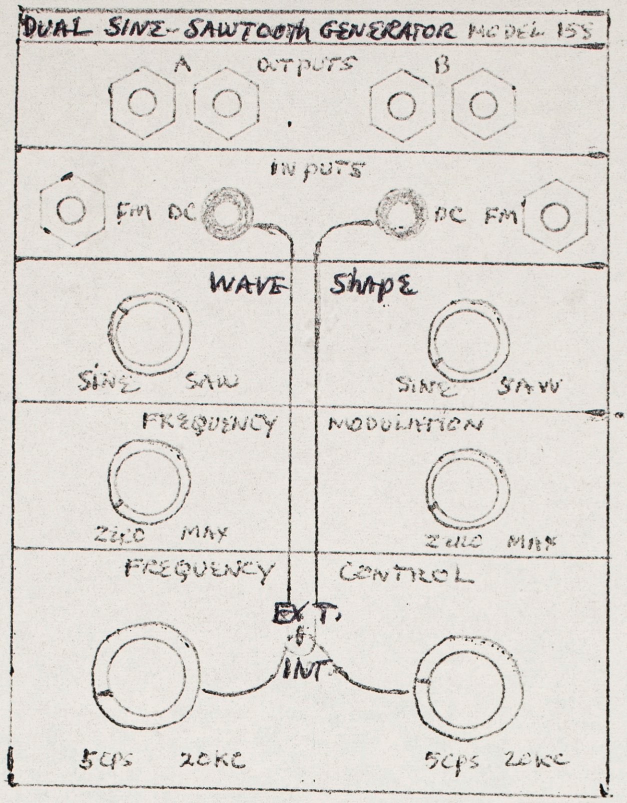
1

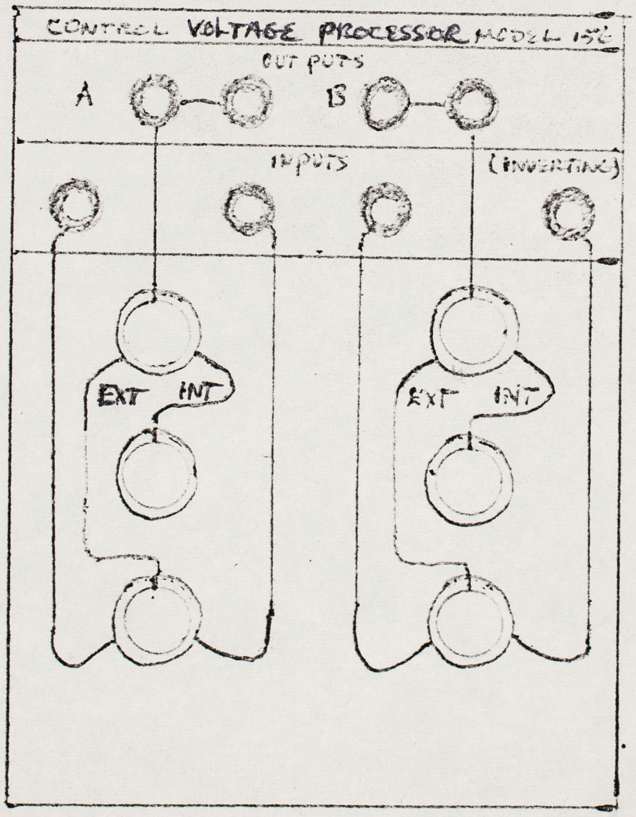
RIGHT CONSOLE


GATE
OUT
IN
MIXER
OUT
1-3
ALL
4-6
IN
SQUARE WAVE
OUT
IN
AMP.
MOD.
FREQ.
MOD.
FREQ.
CONTR.
EXT
INT
WHITE NOISE
OUT
FREQ DIST.
FLAT
1/F
ATTACK GEN.
OUT
IN
ATTACK TIME
DECAY TIME
NOTE DURATION
int. ext.
int. ext.
SINE-SAW GEN.
OUT
IN
WAVE
SHAPE
FREQ.
MOD.
FREQ.
CONTR.
ext.
int
SINE-SAW GEN.
OUT
IN
WAVE
SHAPE
FREQ.
MOD.
FREQ.
CONTR.
ext.
int
WAVE FORM SYNTHESIZER
FREQ MOD.
OUT
IN
FREQ CONTR.
TIMING PULSE GEN.
OUT
alternate
all
IN
Start-stop
Single
Repete
PULSE LENGTH
ext. int
0%
100%
Period
ext. int.
.01"
10"
SEQUENTIAL VOLTAGE SOURCE
No. of Inc.
2
16
IN
OUT
A
B
C
Out
A
B
FINGER PRESSURE


DUAL ATTACK GENERATOR MODEL 180
OUTPUTS
TRIGGER
INPUTS
TRIGGER
ATTACK TIME
.005
1
.005
1
DECAY TIME
.05
5
.05
5
NOTE DURATION
.05
5
.05
5
CONTROLLED INTERNALLY
CONTROLLED BY TRIGGER LENGTH
CONTROLLED INTERNALLY


TIMING PULSE GENERATOR MODEL 140
ALTERNATE
OUTPUTS
ALL PULSES
INPUTS
START
STOP
MODE
START-STOP
SINGLE PULSE
REPETIVE
PULSE LENGTH (PERCENTAGE OF PERIOD)
EXT
INT
0
100
PERIOD (TEMPO)
1 SEC
(TEMPO 60)
EXT
INT
.1 SEC
10 SEC
(TEMPO 600)
(TEMPO 6)


DUAL SINE-SAWTOOTH GENERATOR MODEL 158
A
OUTPUTS
B
INPUTS
FM DC
DC FM
WAVE SHAPE
SINE SAW
SINE SAW
FREQUENCY MODULATION
ZERO MAX
ZERO MAX
FREQUENCY CONTROL
EXT.
INT
5cps 20kc
5cps 20kc


CONTROL VOLTAGE PROCESSOR MODEL 156
OUT PUTS
A
B
INPUTS
(INVERTING)
EXT INT
EXT INT

1	Gate	110	✓
2	Attack	180	✓
3	Pulse	140	✓
4	Volt. Proc	156	✓
5	Random	165	✓
6	En. Detect.	130	✓
7	Sequence	146	
8	VCM		
9	VCF	191	
10	BPF	194	
11	Reverb		
12	Ring Mod		✓
13	Pre Amp		
14	White N.	160	
15	Sine	158	
16	Sq. W		
17	Keyboard	112	
18	Keyboard	114	
19	MIXER	106	✓

Pauline C

October 15, 1968.

Dear Colleague in 1A,

Please get your tape from Carol Sazama. It is to be your record of your improvisation group. Please identify yourself and the list of your students in the group on the back of the tape box. You are to record their attendance on the tape box also. We will then have a written and aural record of their activities during the coming three weeks.

You will note that all improvisation labs, except the one on Wednesday 2-4, will now meet only in 306W. This helps us greatly in distributing instruments and electronic equipment. As you know, many students labored long over the summer months building instruments. We also purchased a few to fill in the gaps in sound. We would like to keep the lab in tact, so please take an extra minute after each lab to replace the equipment. It would be a great help to us if you would also try to evaluate the effectiveness of the various instruments in the labs. Do they have a great utility? a good sound resource? etc?

Thanks again,

John Silber

Buchla System

Patch Panel

Earphone jack?

110 Gate	Patch 124	Pre Amp 170	Mixer 106	Ring 111 Mod
Attack 180	Volt 156 Proc.	144 Sq wave	158 Sine Saw	158 Sine saw
Pulse 140	Sequencer 146 16			

12 Keyboard

112

110 Gate	106 Mixer	Reverb 190	Volt Cont 107 Mixer	
180 Attack	158 Sine Saw	160 White noise	Attack 180	Attack 180
140 Pulse	123 Sequencer 8 123		165 Random Volt	180 ~~Dual~~ Attack

delay time 114

10 Key	10 Volt 10 Pulse

110 GATE	106 MIXER	Cut off Filter 191		165
180 Attack	152 Volt Proc	158 Sine	158	160
140 Pulse	146 Sequencer			

110 Gate	106 Amp	190 Reverb	130 Envelope	194 BP Filter
180 Attack	156 Volt	158 Sine	158 Sine	130 Env Detector
140 Pulse	146 Sequencer			

112

12 Key

Intro to Electronic Sound

Instrumentation

Explanation of Studio hook ups patching etc.

9/26/67

NOTICE TO ALL FACULTY

Because it may be useful in answering some problems concerning student advising the following is a list of the faculty seminars being offered this academic year in the Contemporary Issues Program in John Muir College. Students must choose now for seminars in the Winter and Spring quarters if they opt to take the faculty seminars rather than the lecture-discussion meetings as a means of fulfilling their contemporary issues requirement.

Fall

Seymour Harris, "Public Policy: Economic and Non-Economic Aspects"

Robert M. Carmack, "The Scientific Study of Race"

Charles D. Tarlton, "The Philosophy and Rhetoric of Rejection"

Winter

Ferren MacIntyre, "The Conservation of Aesthetic Resources"

Jean Mandler, "On the Meaning of Anxiety"

Joseph Stokes, "World Peace through World Law"

Robert Livingston,

Spring

Herbert York, "Science and Public Policy"

Andre Rosfelder and Piero Ariotti, "The Scientist and the Artist"

Keith Lowe, "Malcolm X and the Black Left"

Robert Hamburger, "Problems of Public Health in Developing Areas"

Although system output may be derived from any audio module output, it is typically derived from the gate which provides signal level control and leakage prevention from unwanted signals.

The voltage controlled gate requires two inputs: one is any audio signal which is to be passed through the gate, two is a control voltage (constant [red]) or [variable [black]) which opens the gate at the level of the control voltage when the gates' potentiometer is set at maximum.

Control voltage sources are the keyboards, sequencers, random voltage generators, ~~pulse generators~~, attack generators ~~and~~ voltage processors. and envelope detectors. Trigger sources are: keyboards, sequencers, pulse generators and any control voltage at 10 volts or more.

Audio sources are sine-sawtooth generators, square wave generators, white noise generators and microphone preamps. Plus any line level external audio source

Audio processors are voltage controlled gates, mixers, filters, reverberators and modulators.

Frequency (Pitch) control

Frequency control of sine-sawtooth and squarewave generators is manual when the toggle switch is at internal position. For voltage control of frequency the switch must be at external position and the DC input connected with a voltage source (variable).

RULES FOR USE OF BUCHLA BOXES

1. BOXES MAY BE CHECKED OUT FROM THE ELECTRONICS LAB Q 315 ONE AT A TIME FOR USE IN Q314 EDITING STATIONS AT SPECIFIED TIMES.

2. BOX IS CHARGED TO ONE PERSON ONLY UNLESS THERE IS AN AUTHORIZED COLLABORATION. PLEASE DO NOT INVITE YOUR FRIENDS.

3. PATCH CORD SETS GO WITH THE BOX AND MUST ALL BE RETURNED TO Q 315. PULL PATCH CORDS FROM JACKS BY THE PLUG TO PROLONG LIFE OF PATCH CORDS.

4. ALL EQUIPMENT SHOULD BE HANDLED GENTLY TO KEEP MAINTENANCE AT MINIMUM.

5. PLEASE REPORT ANY MALFUNCTIONING TO JIM CAMPBELL OR PAULINE OLIVEROS. DO NOT ATTEMPT MAINTENANCE ON YOUR OWN.

6. DO NOT LEAVE BOX OR PATCH CORD SET IN EDITING STATION. RETURN ALL EQUIPMENT TO Q 315.

THE SYSTEM

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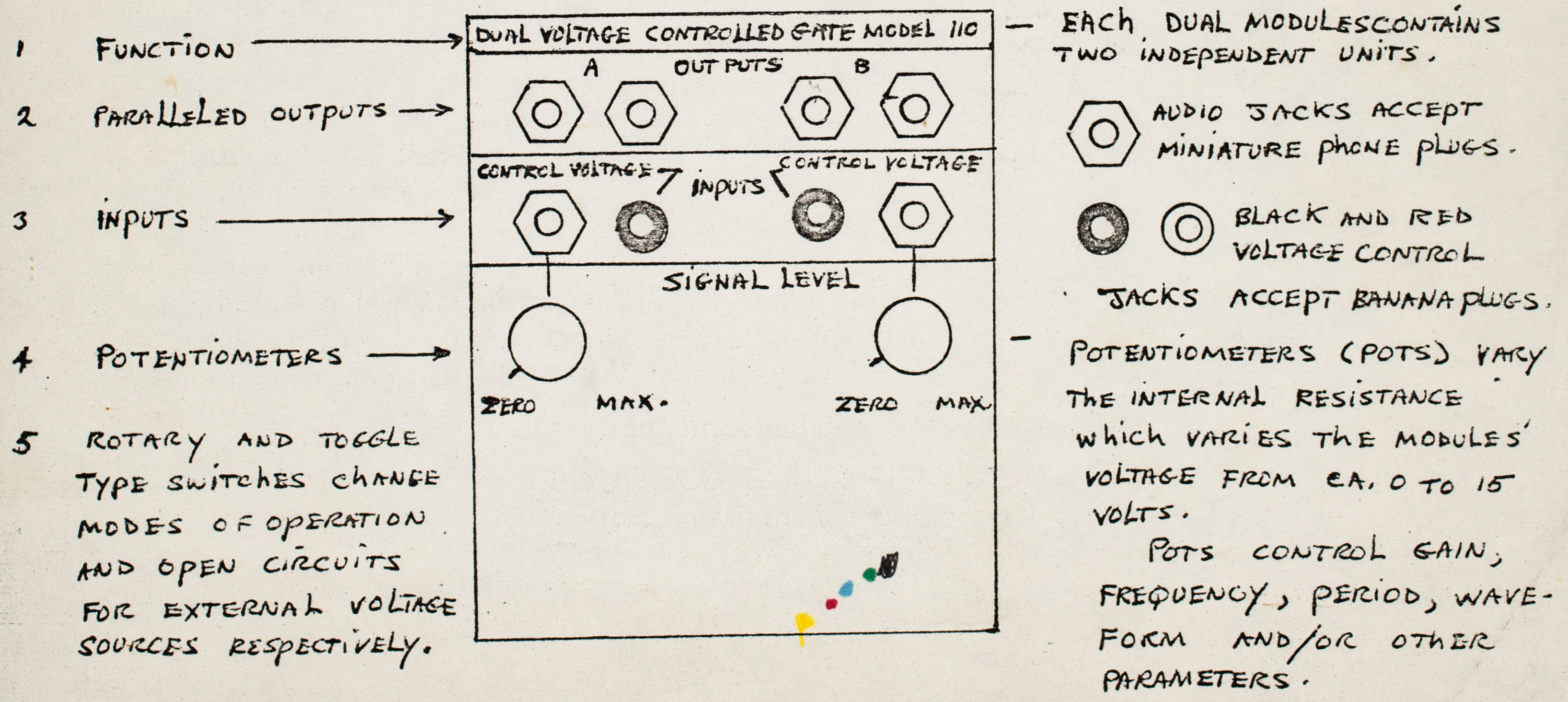
The rules for interconnection are straight-forward. Any number of inputs may be connected to a single output. Timing pulse outputs may be paralleled and connected to one input. The system output may be derived from any module; output is of sufficient magnitude to drive line inputs on tape recorders or sensitive inputs on power amplifiers.

PANEL FORMAT



1 FUNCTION →

2 PARALLELED OUTPUTS →

3 INPUTS →

4 POTENTIOMETERS →

5 ROTARY AND TOGGLE TYPE SWITCHES CHANGE MODES OF OPERATION AND OPEN CIRCUITS FOR EXTERNAL VOLTAGE SOURCES RESPECTIVELY.

– EACH DUAL MODULES CONTAINS TWO INDEPENDENT UNITS.

AUDIO JACKS ACCEPT MINIATURE PHONE PLUGS.

BLACK AND RED VOLTAGE CONTROL JACKS ACCEPT BANANA PLUGS.

– POTENTIOMETERS (POTS) VARY THE INTERNAL RESISTANCE WHICH VARIES THE MODULES' VOLTAGE FROM CA. 0 TO 15 VOLTS.

POTS CONTROL GAIN, FREQUENCY, PERIOD, WAVEFORM AND/OR OTHER PARAMETERS.

Although system output may be derived from any audio module output, it is typically derived from the gate which provides signal level control and leakage prevention from unwanted signals.

The voltage controlled gate requires two inputs: one is any audio signal which is to be passed through the gate, two is a control voltage (constant [red]) or [variable [black]) which opens the gate at the level of the control voltage when the gates' potentiometer is set at maximum.

Voltage sources are the keyboards, sequencers, random voltage generators, pulse generators, attack generators ~~and~~ voltage processors. and Envelope detectors.

Audio sources are sine-sawtooth generators, square wave generators, whitenoise generators and microphone preamps.

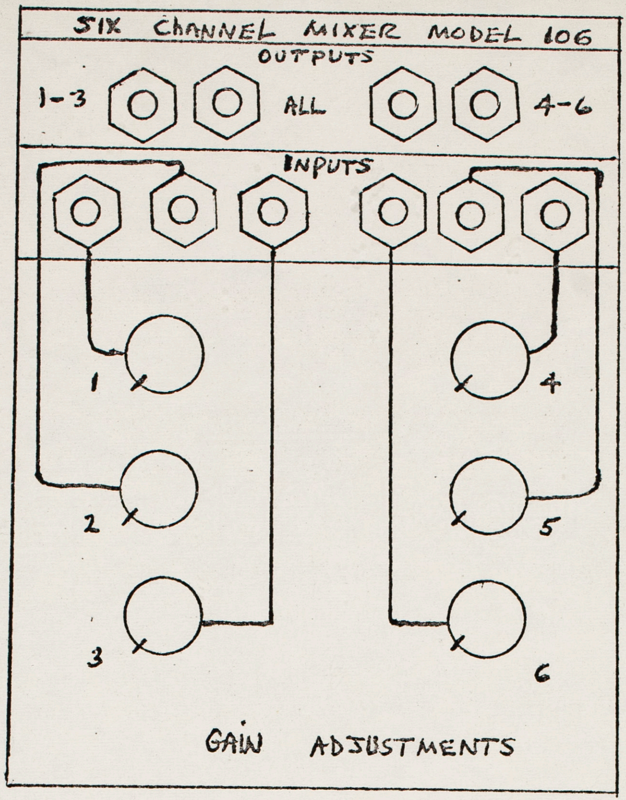
Audio processors are voltage controlled gates, mixers, filters, reverberators, modulators.

Frequency (Pitch) control

Frequency control of sine-sawtooth and squarewave generators is manual when the toggle switch is at internal position. For voltage control of frequency the switch must be at external position and the DC input connected with a voltage source (variable).

MAY BE OPERATED AS 2 THREE CHANNEL MIXERS ARE 1 SIX CHANNEL MIXER.

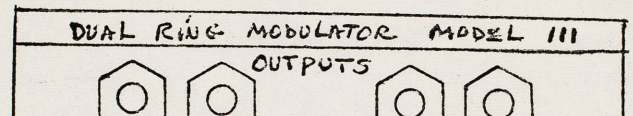
OUTPUT 180° OUT OF PHASE WITH INPUT.


SIX CHANNEL MIXER MODEL 106
OUTPUTS
1-3
ALL
4-6
INPUTS
1
2
3
4
5
6
GAIN ADJUSTMENTS

TO GATE OR ANY AUDIO INPUT.

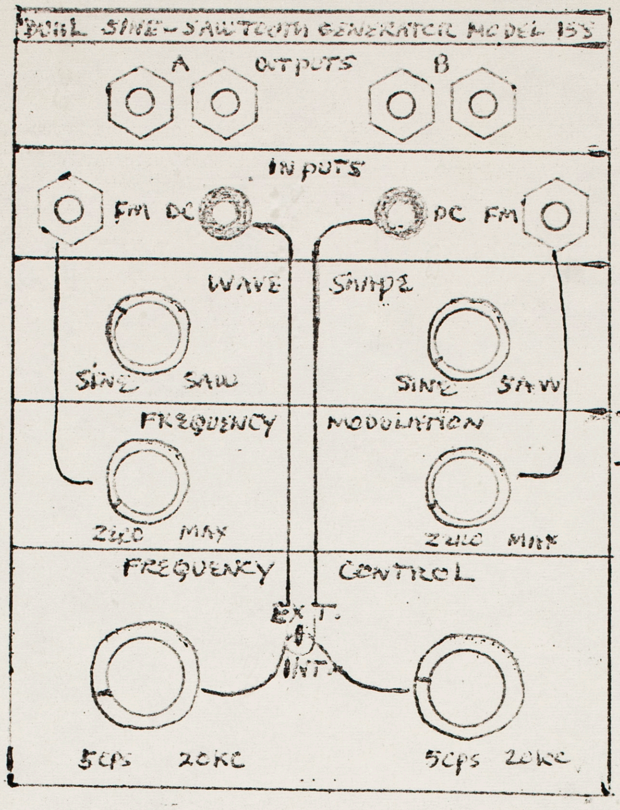
INPUT MAY BE DERIVED FROM ANY AUDIO OUTPUT.

POTS CONTROL GAIN OF EACH INPUT SEPARATELY


DUAL RING MODULATOR MODEL 111
OUTPUTS
INPUTS

RING MODULATOR REQUIRES 2 SEPARATE AUDIO SIGNALS. THE FUNDAMENTALS ARE SUPPRESSED AND THE SUMS AND DIFFERENCES (COMBINATION TONES) ARE AMPLIFIED.
USE OF THE SIX CHANNEL MIXER OR GATE IS RECOMMENDED FOR GAIN BALANCING BETWEEN THE TWO AUDIO SIGNALS.

WAVE SHAPE POTS
. ADD HARMONICS CONTINUOUSLY
FROM CA. 2% TO 60%
(SINE TO SAWTOOTH)

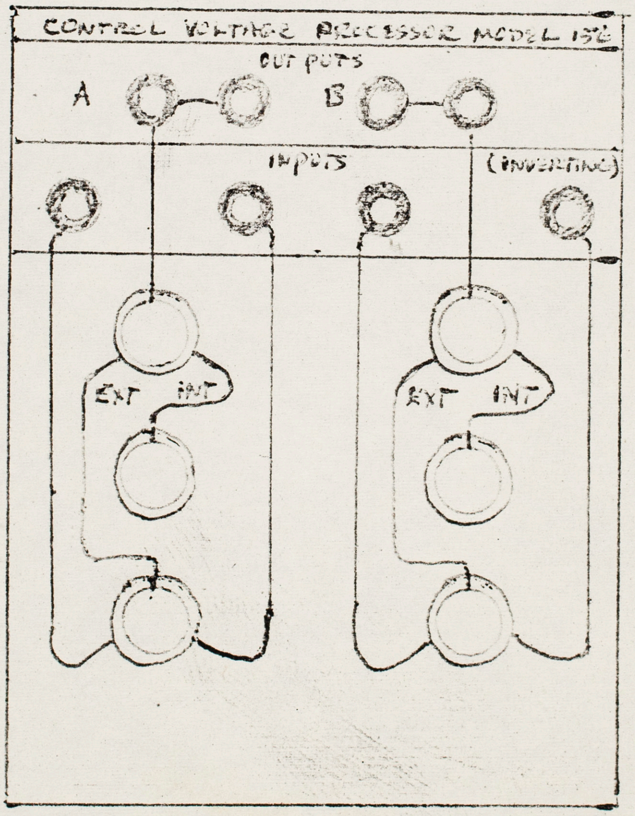

DUAL SINE-SAWTOOTH GENERATOR MODEL 155
A
OUTPUTS
B
INPUTS
FM DC
DC FM
WAVE
SHAPE
SINE SAW
SINE SAW
FREQUENCY
MODULATION
ZERO MAX
ZERO MAX
FREQUENCY
CONTROL
EXT.
INT.
5CPS 20KC
5CPS 20KC

TO GATE OR OTHER AUDIO PROCESSING MODULES OR DIRECTLY TO AMPLIFIER.

FM INPUT: FROM ANOTHER AUDIO SOURCE I.E. OPPOSITE SIDE OF DUAL GENERATOR, WHITE NOISE, OUT PUT OF MIXER OR OTHER PROCESSORS.

DC INPUT: WHEN TOGGLE SWITCH SET TO EXT., FREQUENCY IS CONTROLLED BY VOLTAGE SOURCES SUCH AS SEQUENCER OR KEY BOARD. THE ASSOCIATED FM POTENTIOMETER CONTROLS THE AMPLITUDE OF THE MODULATING SIGNAL.

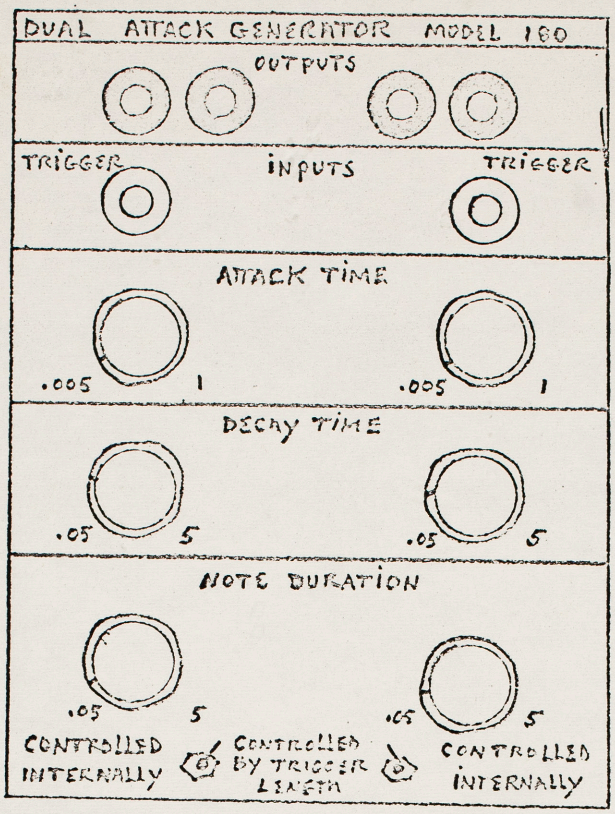
TOGGLE SWITCH MUST BE SET ON EXT. INORDER TO CONTROL FREQUENCY FROM AN EXTERNAL VOLTAGE SOURCE.


CONTROL VOLTAGE PROCESSOR MODEL 156
OUT PUTS
A
B
INPUTS
(INVERTING)
EXT INT
EXT INT

TO DC INPUTS OF GENERATORS OR GATE.

FROM VOLTAGE SOURCES.

- MIXES INTERNAL VOLTAGE WITH EXTERNAL VOLTAGES ALGEBRAICLY IN ASSOCIATION WITH LOWER TWO POTS.
- INTERNAL VOLTAGE POT CA 0-15 VOLTS. WILL HOLD GATE OPEN AT CONSTANT LEVEL WHEN UPPER POT IS AT INT. SETTING.
- CONTROLS AMOUNT OF EXTERNAL VOLTAGES. APPROXIMATELY 50/50 AT 12 O'CLOCK SETTING.


DUAL ATTACK GENERATOR MODEL 180
OUTPUTS
TRIGGER
INPUTS
TRIGGER
ATTACK TIME
.005
1
.005
1
DECAY TIME
.05
5
.05
5
NOTE DURATION
.05
5
.05
5
CONTROLLED INTERNALLY
CONTROLLED BY TRIGGER LENGTH
CONTROLLED INTERNALLY

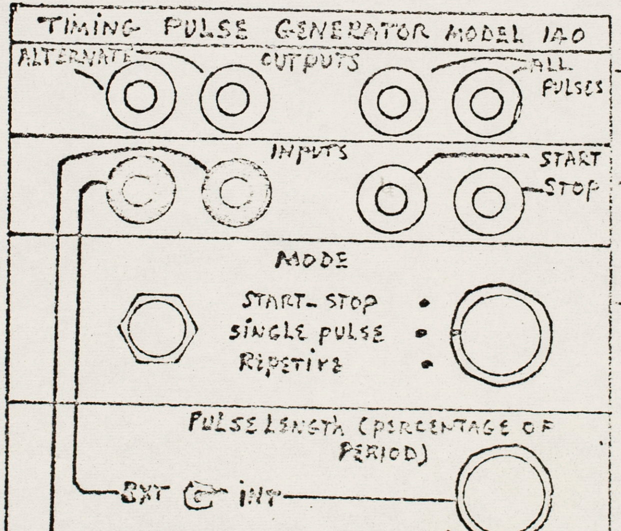
→ TO GATE

→ FROM PULSE GENERATOR, KEYBOAR
SEQUENCER (OR RANDOM VOLTAGE SOUR

→ CONTIUOSLY VARIABLE

" " "

LENGTH OF NOTE CAN BE CONTROLLED BY KEYBOARD OR OTHER VOLTAGE SOURCE WHEN SWITCH IS SET TO TRIGGER LENGTH CONTROL


TIMING PULSE GENERATOR MODEL 140
ALTERNATE
OUTPUTS
ALL PULSES
INPUTS
START
STOP
MODE
START-STOP
SINGLE PULSE
RIPETIVE
PULSE LENGTH (PERCENTAGE OF PERIOD)
EXT
INT
0
100
PERIOD (TEMPO)
1 SEC
(TEMPO 60)
EXT
INT
.1 SEC
10 SEC
(TEMPO 600)
(TEMPO 6)

ALTERNATE PULSES DIVIDES REPETITION RATE BY 2 AND PRESENTS ALTERNATE PULSES AT EACH OUTPUT.

MOMENTARY CONTACT SWITCH; OPERATED MANUALLY IN SINGLE PULSE MODE.

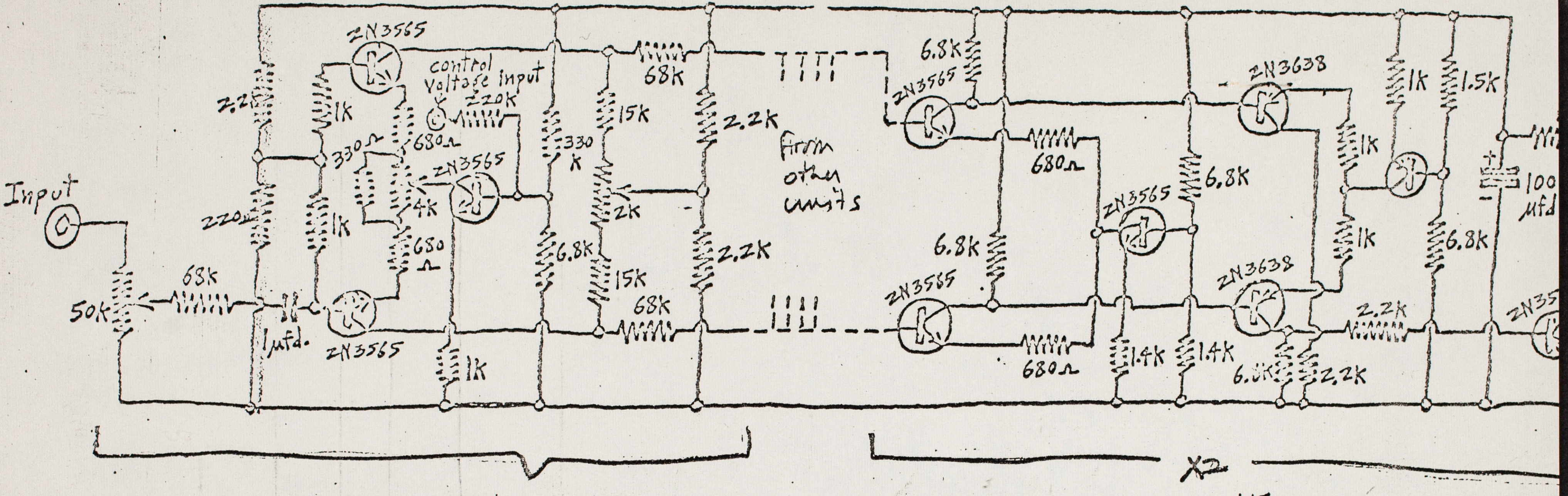
TOGGLE SWITCH - PULSE LENGTH MAYBE CONTROLLED BY EXTERNAL VOLTAGE SOURCE I.E. KEYBOARD OR SEQUENCER OR RANDOM VOLTAGE GENERATOR.

PERIOD ~~MAY~~ CAN BE CONTROLLED BY EXTERNAL VOLTAGE SOURCE.

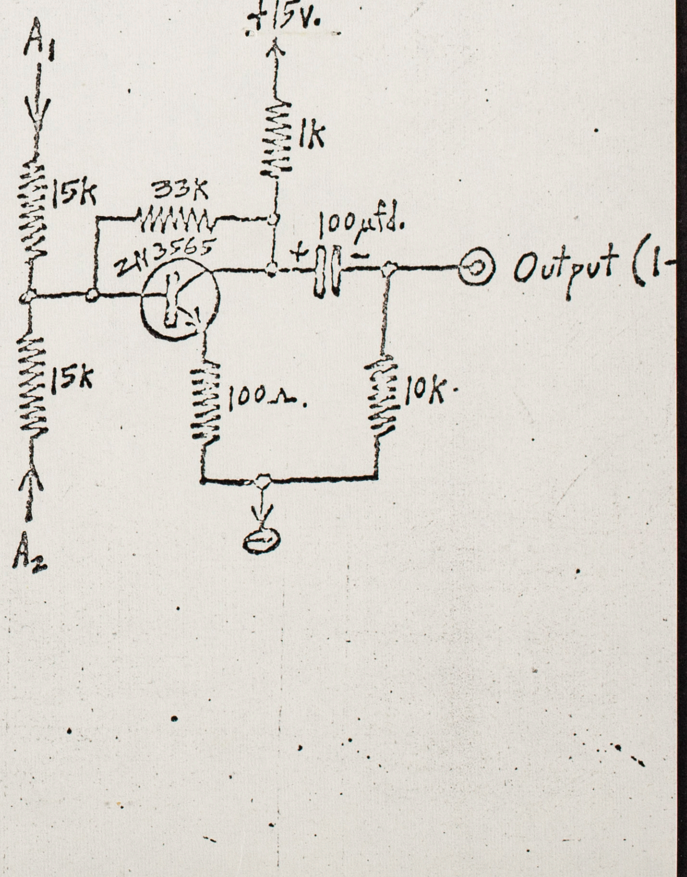
→ TO RED TRIGGER INPUTS I.E. ATTACK GENERATOR, SEQUENTIAL VOLTAGE SOURCE OR GATE. (GATE CONTROL VOLTAGE INPUT IS BLACK)

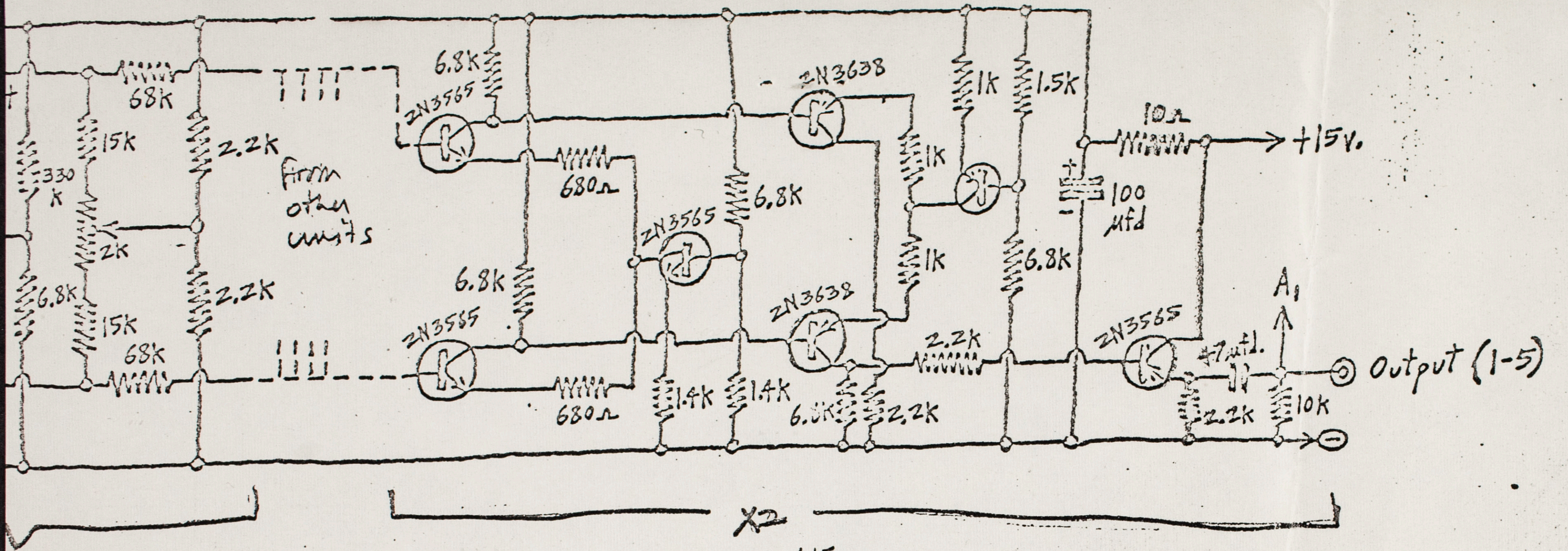
IN START-STOP MODE, START AND STOP INPUTS MAY BE TRIGGERED FROM AN EXTERNA
SOURCE I.E. KEYBOARD OR SEQUENCER

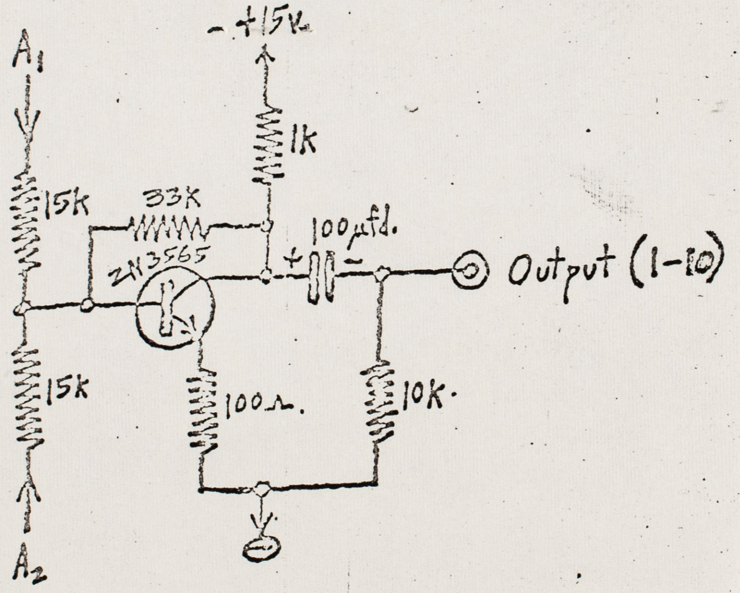
REPETITIVE MODE : PULSE REPEATS CONTINUOSLY. ACCORDING TO SETTINGS OF PULSE LENGTH AND PERIOD POTENTIOMETERS


Input
50k
68k
1µfd.
2.2k
220Ω
1k
330Ω
680Ω
4k
680 Ω
2N3565
control voltage input
220k
330 k
6.8k
15k
2k
68k
2.2k
From other units
6.8k
680Ω
1.4k
2N3638
1k
1.5k
100 µfd
2.2k
6.8k
X10
X2

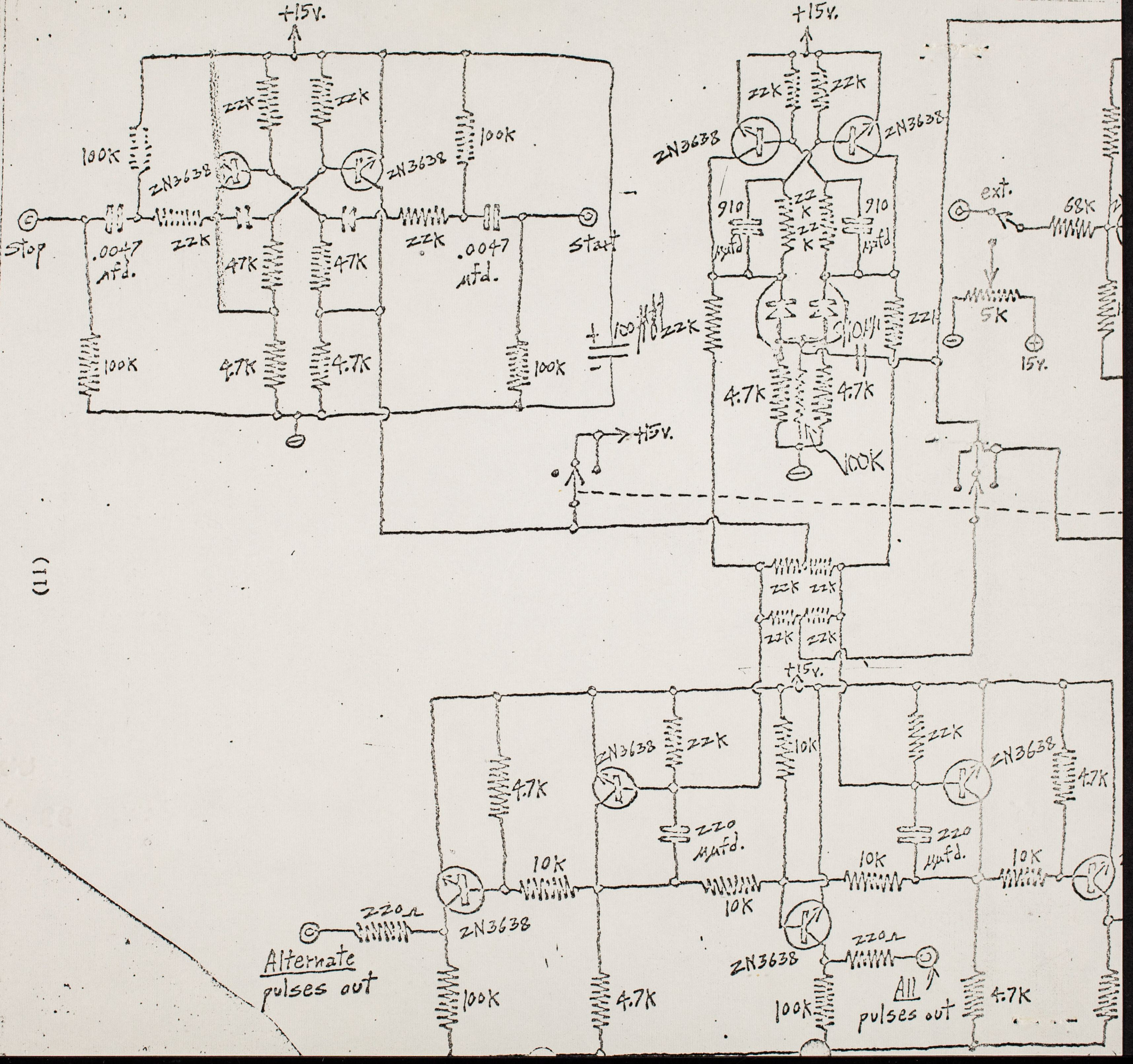
Buchla Voltage-controlled Mixer (10 channels)(model 107)

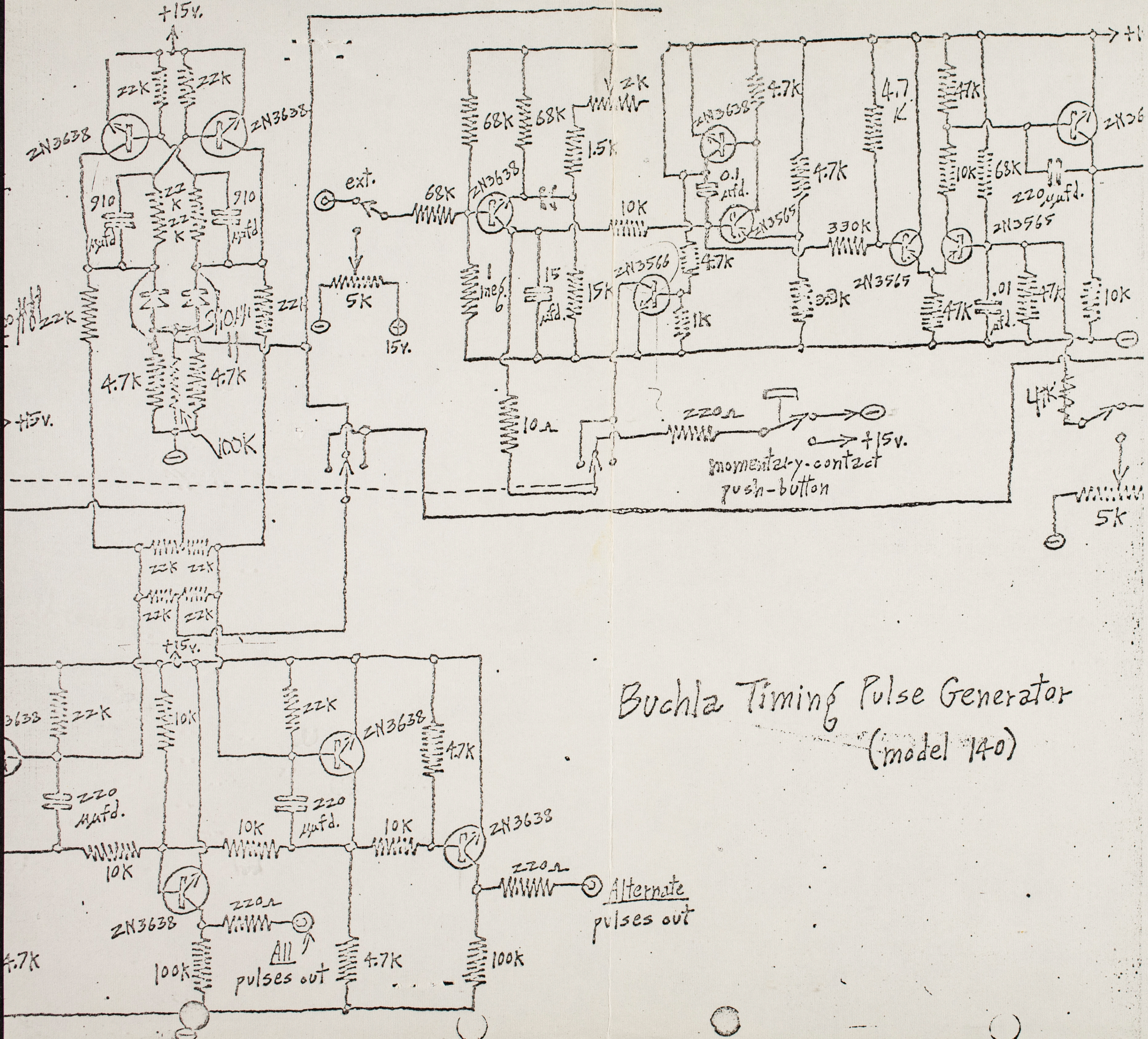

+15v.
A1
A2
15k
15k
33k
1k
2N3565
100µfd.
100Ω.
10k.
Output (1-


68k
15k
330 k
2.2k
from other units
2k
6.8k
15k
68k
2.2k
6.8k
2N3565
680Ω
6.8k
2N3565
2N3638
1k
1.5k
10Ω
+15v.
1k
+
100 µfd
-
6.8k
6.8k
2N3565
1k
6.8k
2N3638
2N3565
2.2k
A1
47µfd.
Output (1-5)
1.4k
1.4k
680Ω
6.8k
2.2k
2.2k
10k
X2


+15v.
A1
1k
15k
33K
100µfd.
+
-
2N3565
Output (1-10)
15k
100Ω.
10K.
A2

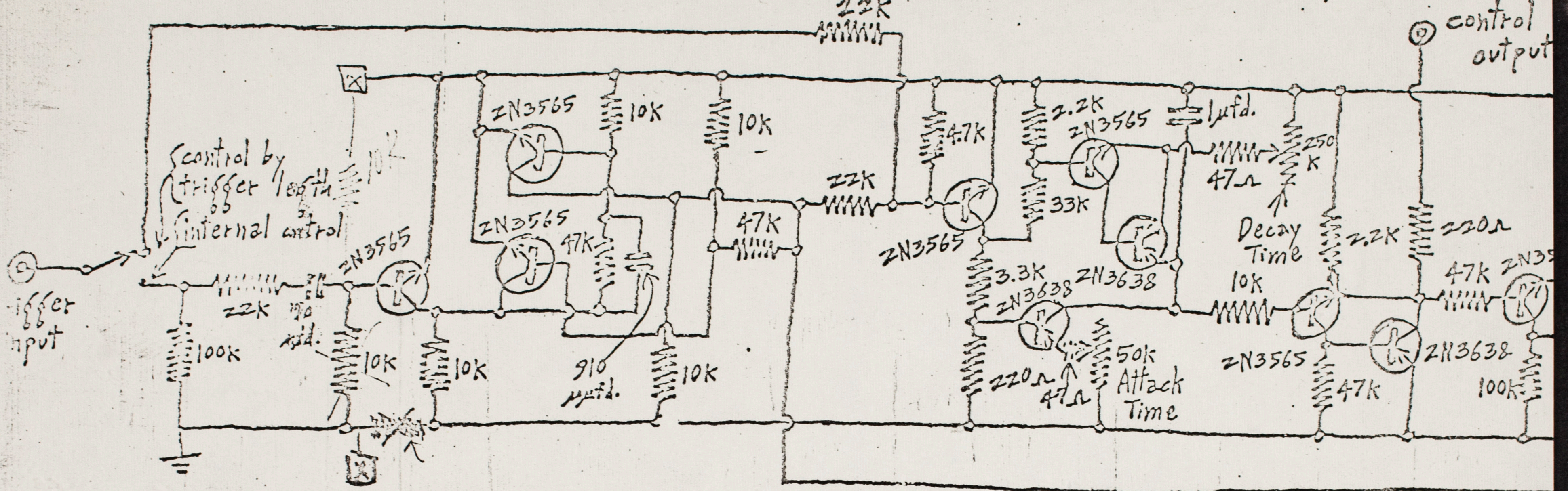
ixer .(10 channels)(model 107)


+15v.
+15v.
+15v.
+15v.
100K
22K
22K
100K
2N3638
2N3638
2N3638
2N3638
Stop
.0047 mfd.
22K
22K
.0047 mfd.
Start
47K
47K
100K
4.7K
4.7K
100K
+ 100 mfd −
22K
910 μμfd
22K
22K
910 μμfd
22K
4.7K
4.7K
100K
ext.
68K
5K
15v.
22K
22K
22K
22K
4.7K
22K
10K
22K
4.7K
220 μμfd.
220 μμfd.
10K
10K
10K
10K
220Ω
220Ω
Alternate pulses out
All pulses out
100K
4.7K
100K
4.7K



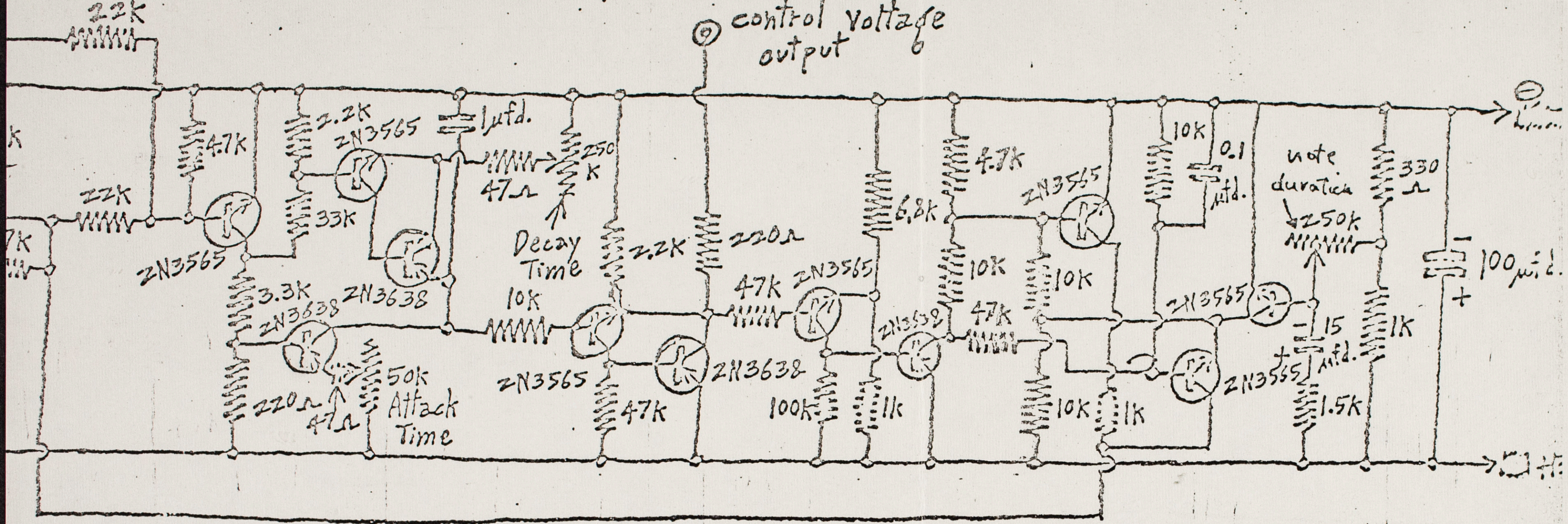
Buchla Timing Pulse Generator
(model 140)

+15v.
22k
22k
2N3638
2N3638
910 μμfd
22 K
22 K
910 μμfd
22k
22k
4.7k
4.7k
100K
+15v.
ext.
68K
5K
15v.
68K
68K
2K
1.5K
2N3638
10K
1 meg.
15 μfd.
15K
2N3566
4.7K
1K
2N3638
4.7K
0.1 μfd.
2N3565
4.7K
3.3K
330K
4.7 K
47K
2N3565
2N3565
10K
68K
220 μμfd.
2N36
47K
.01 μfd.
47K
10K
+1
10 Ω
220 Ω
momentary-contact push-button
+15v.
4.7K
5K
22K
22K
22K
22K
+15v.
2N3638
22K
10K
22K
2N3638
4.7K
220 μμfd.
220 μμfd.
10K
10K
10K
2N3638
2N3638
220 Ω
220 Ω
Alternate pulses out
All pulses out
4.7K
100K
4.7K
100K


22K
control output
control by trigger length
internal control
trigger input
10K
22K
.0 μfd.
100K
2N3565
10K
10K
2N3565
10K
10K
2N3565
47K
47K
910 μμfd.
10K
22K
4.7K
2.2K
2N3565
1μfd.
47Ω
250 K
33K
2N3565
2N3638
Decay Time
3.3K
2N3638
2N3638
220Ω
47Ω
50K Attack Time
10K
2N3565
2.2K
47K
220Ω
47K
2N3638
100K

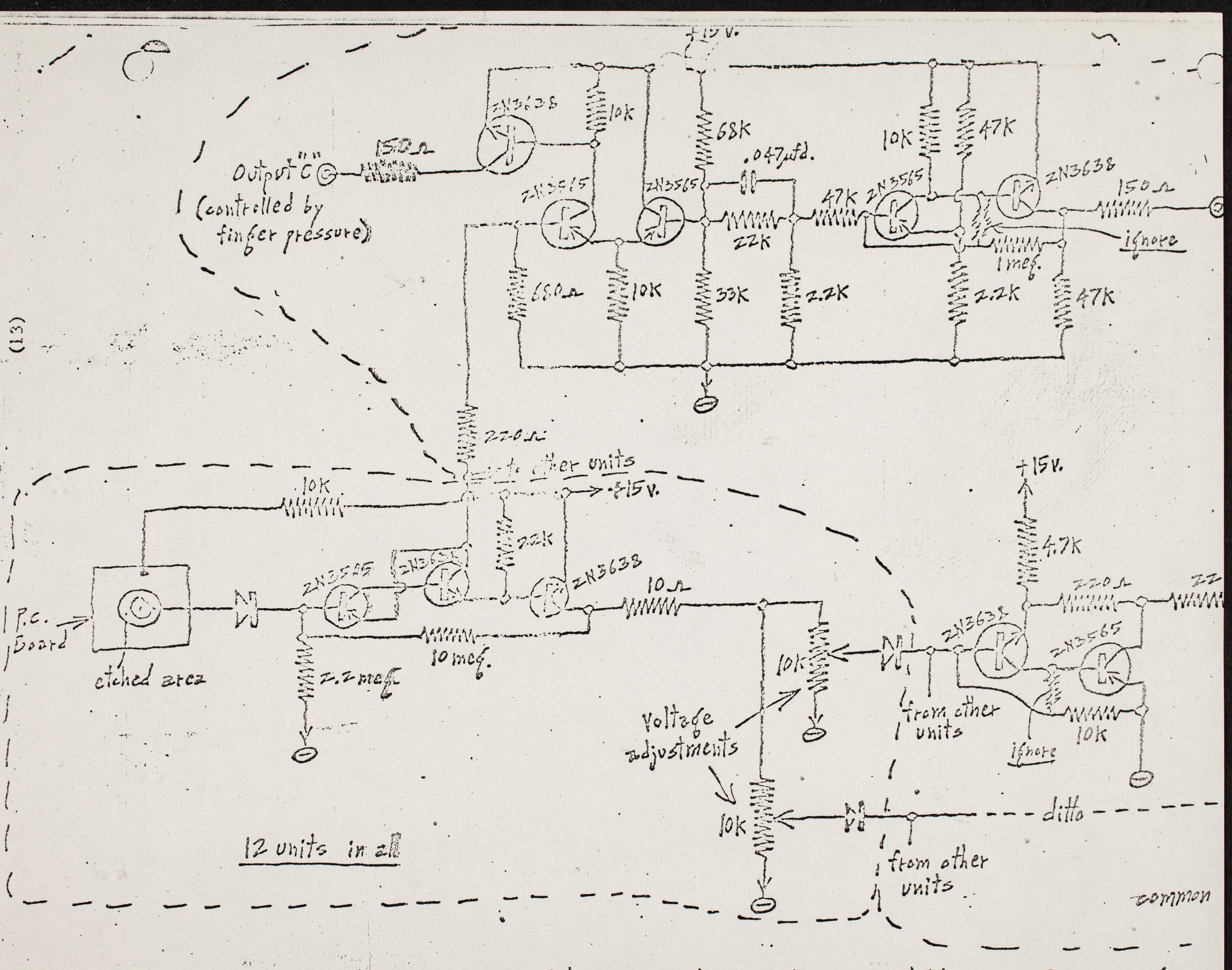
½ Buchla Dual Attack Generator (model 180)

☒ NOTE ERROR IN RUNNING RESISTOR TO +15.
SHOULD BE RUN TO GROUND.

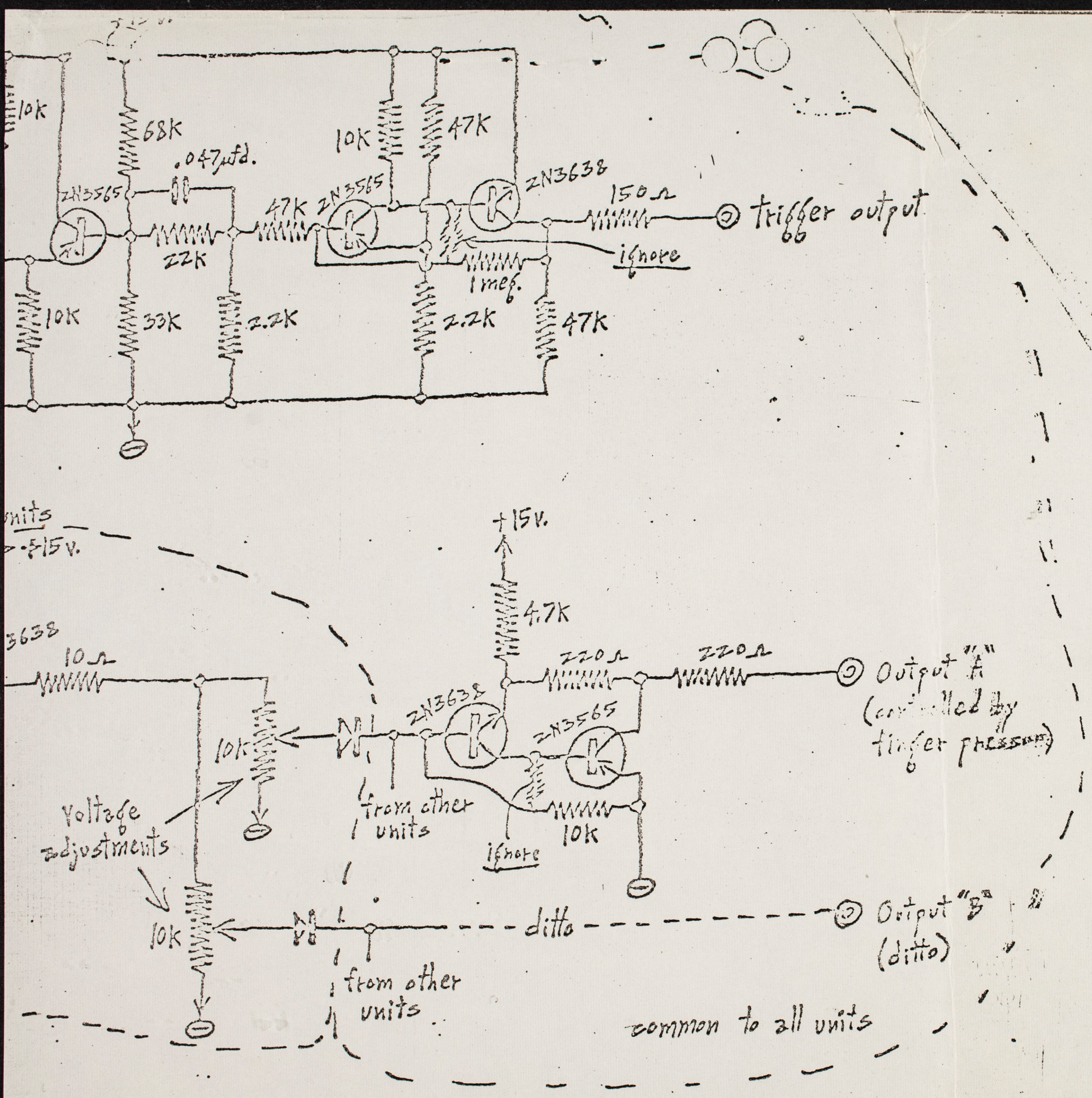

control voltage output
22K
22K
47k
2.2K
2N3565
1µfd.
47Ω
250 K
Decay Time
33K
2N3565
2N3638
2N3638
3.3K
10k
2.2K
220Ω
47k
2N3565
2N3565
2N3638
47k
220Ω
47Ω
50k
Attack Time
6.8k
4.7k
10K
10K
2N3565
2N3638
47k
100k
1k
10K
1k
10K
0.1 µfd.
2N3565
2N3565
note duration
250k
330 Ω
15 µfd.
1.5K
1K
100µfd.
+
−

al Attack Generator (model 180)

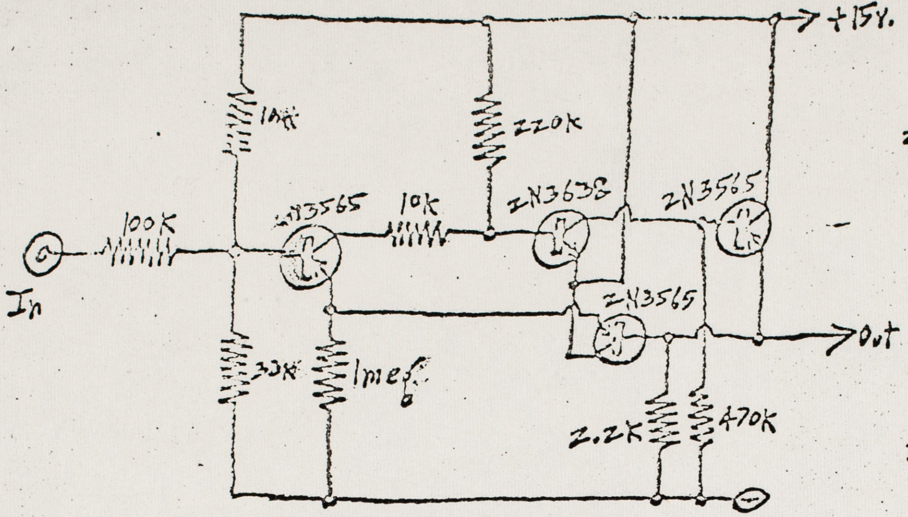
+15.


+15v.
2N3638
10K
68K
.047 µfd.
10K
47K
2N3638
150Ω
150Ω
Output "C"
(controlled by finger pressure)
2N3565
2N3565
47K
2N3565
22K
ignore
1 meg.
68Ω
10K
33K
2.2K
2.2K
47K
220Ω
to other units
10K
+15v.
22K
2N3565
2N3638
2N3638
10Ω
P.C. Board
etched area
2.2 meg
10 meg.
+15v.
4.7K
220Ω
22
2N3638
2N3565
10K
from other units
ignore
10K
Voltage adjustments
10K
ditto
from other units
12 units in all
common

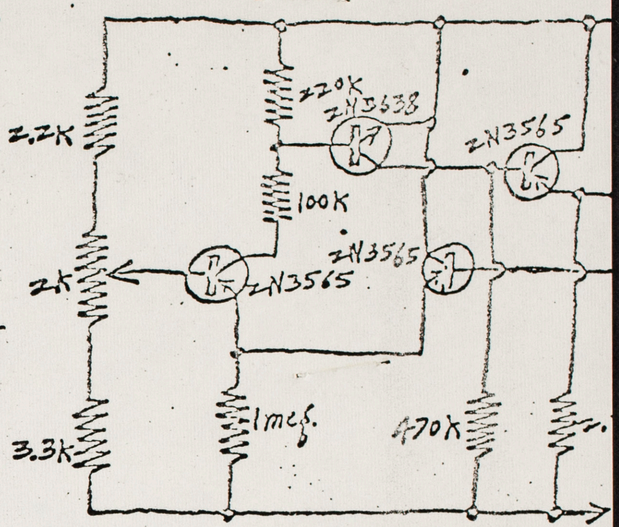
Buchla Touch-controlled Voltage Source (mode


10K
68K
.047 μfd.
10K
47K
2N3565
2N3565
2N3638
150 Ω
trigger output
ignore
22K
47K
1 meg.
10K
33K
2.2K
2.2K
47K
units
+15 v.
+15 v.
4.7K
3638
10 Ω
220 Ω
220 Ω
Output "A"
(controlled by
finger pressure)
2N3638
2N3565
10K
from other
units
ignore
10K
Voltage
adjustments
10K
ditto
Output "B"
(ditto)
from other
units
common to all units

Touch-controlled Voltage Source (model 112)

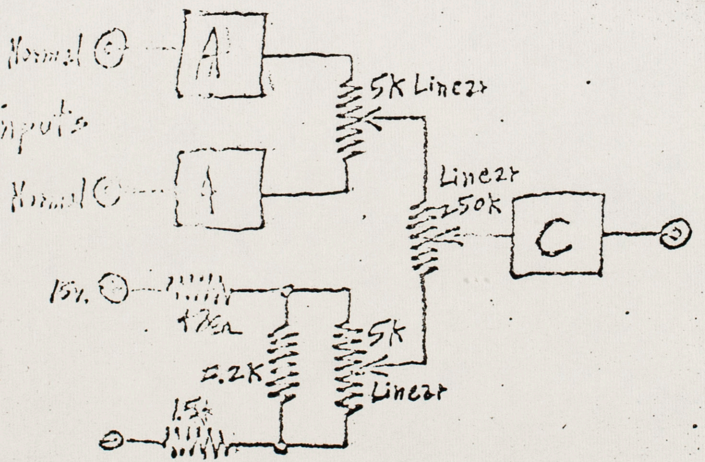

+15v.
1K
220K
In
100K
2N3565
10K
2N3638
2N3565
2N3565
Out
33K
1meg.
2.2K
470K

(A)

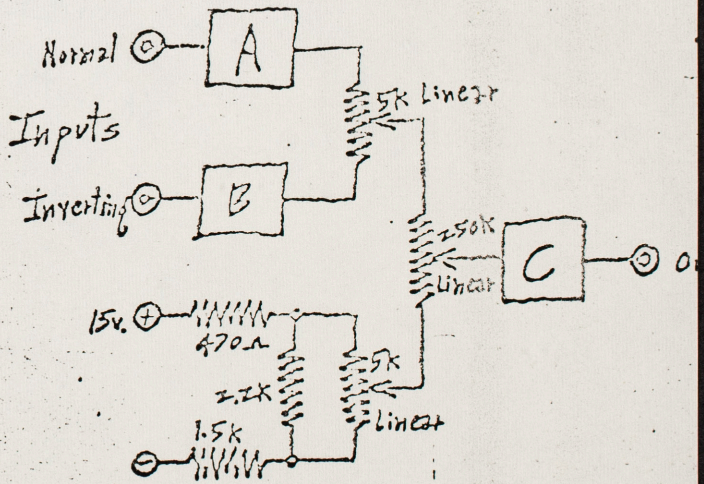

2.2K
220K
2N3638
2N3565
100K
2K
2N3565
2N3565
1meg.
470K
3.3K

(B)

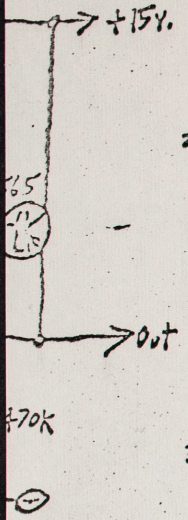
(6)

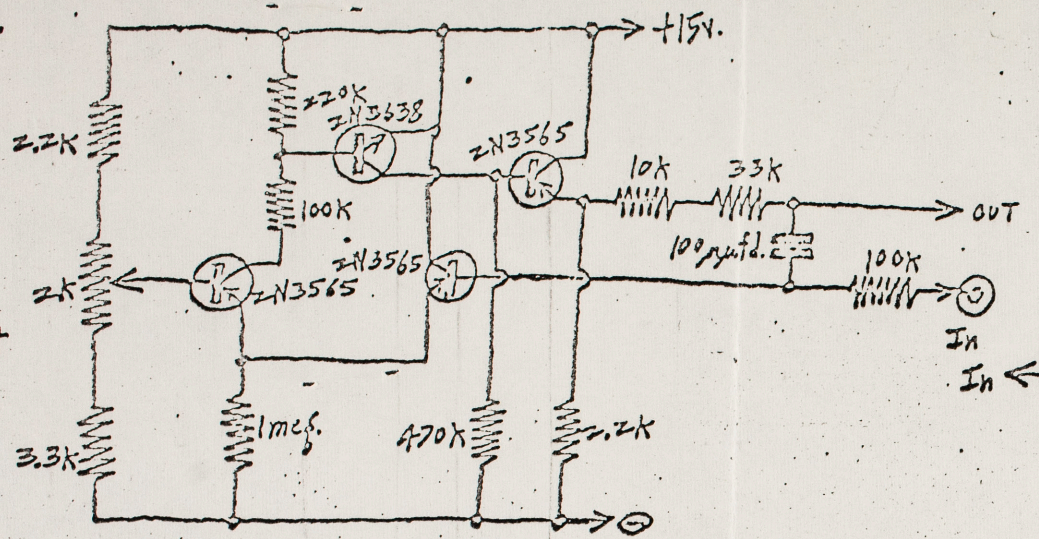

Normal
A
Inputs
Normal
A
5K Linear
Linear
250K
C
15v.
470Ω
2.2K
5K
Linear
1.5k

Left half

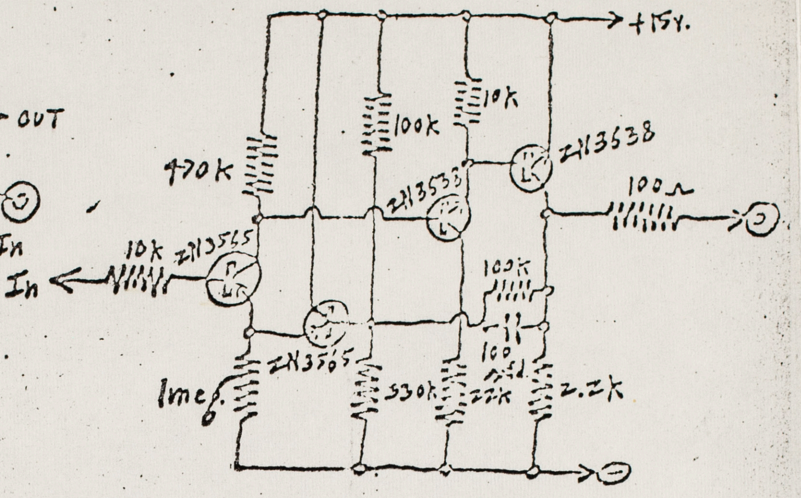

Normal
A
Inputs
Inverting
B
5K Linear
250K
Linear
C
15v.
470Ω
2.2K
5K
Linear
1.5K

Right half

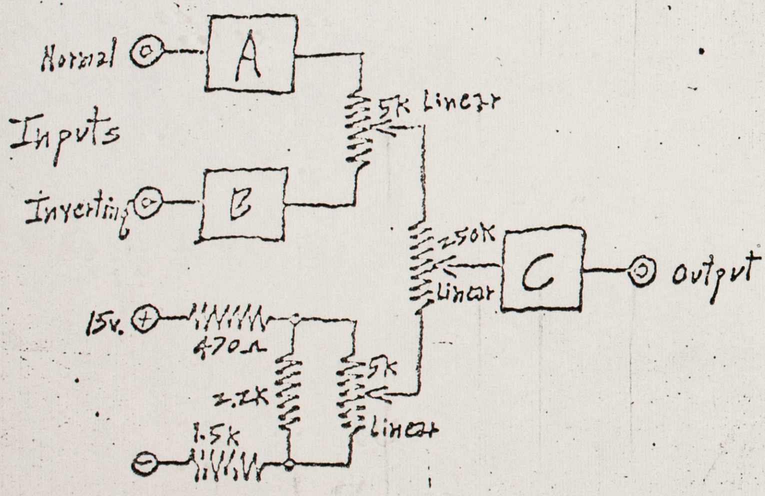

+15v.
65
Out
470K


+15v.
2.2K
220K
2N3638
2N3565
100K
2K
2N3565
2N3565
10K
33K
OUT
100 μμfd.
100K
In
1meg.
470K
2.2K
3.3K

(B)

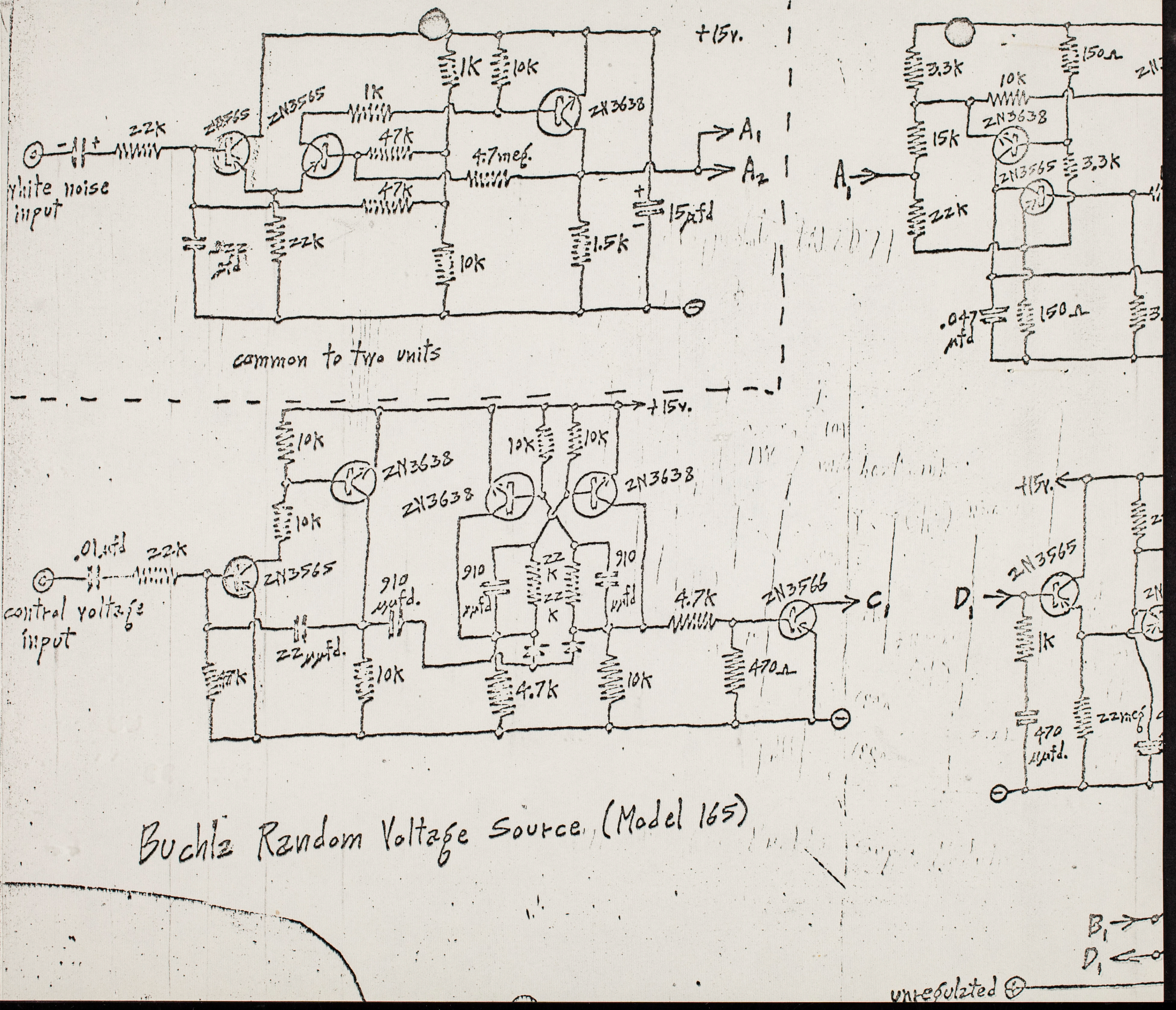

+15v.
470K
100K
10K
2N3638
2N3638
100Ω
10K
2N3565
In
100K
100 μμfd.
2N3565
1meg.
330K
22K
2.2K

(c)

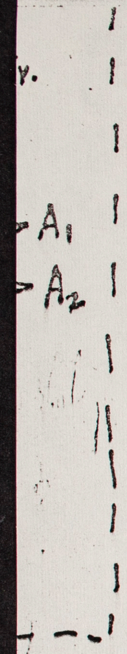

Normal
A
Inputs
Inverting
B
5K Linear
250K
Linear
C
output
15v.
470Ω
2.2K
5K
Linear
1.5K

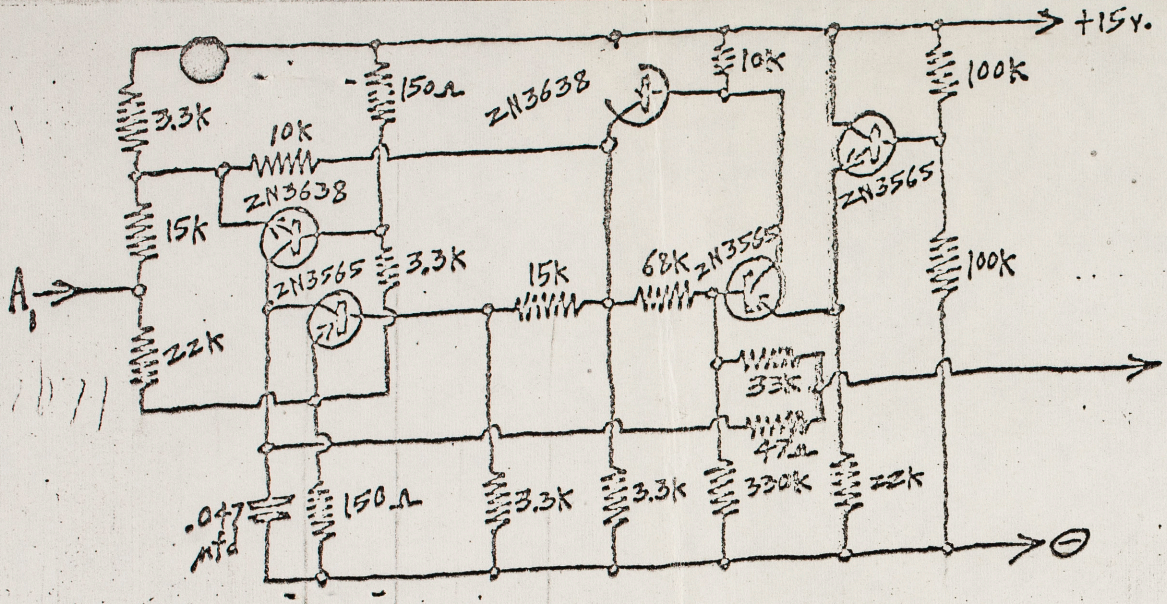
Right half

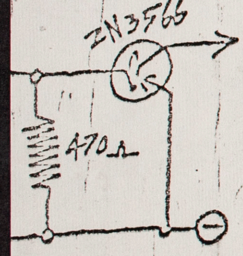
Buchla Control Voltage Processor (model 156)

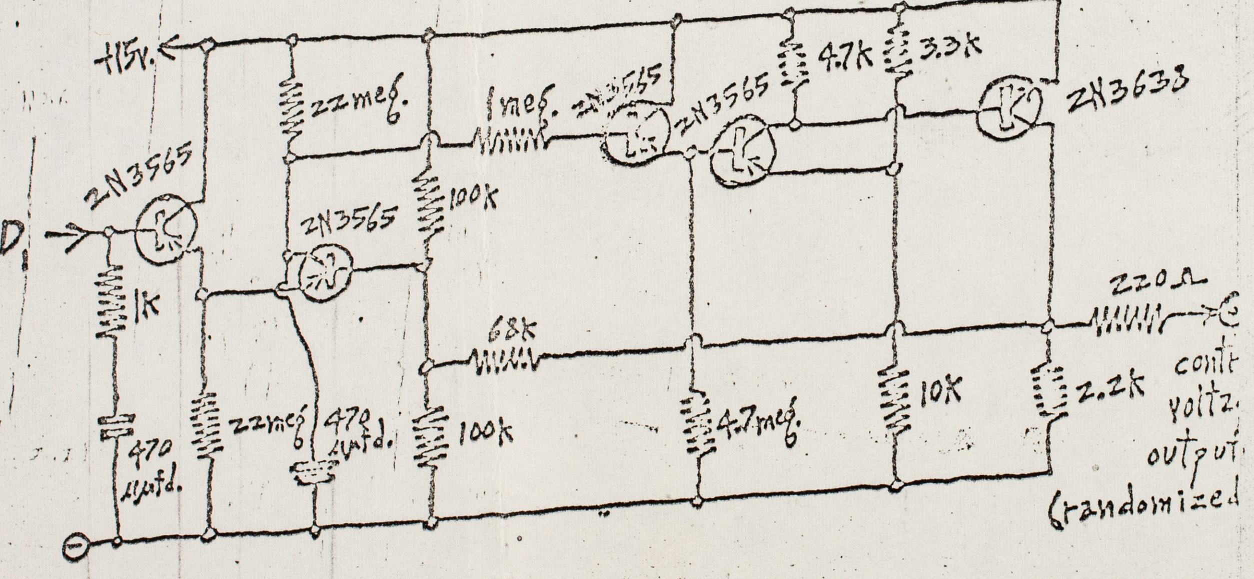

+15v.
white noise input
22k
2N3565
2N3565
1K
1K
10k
2N3638
47k
4.7meg.
A1
A2
47k
15μfd
22 μfd
22k
10k
1.5k
common to two units
+15v.
10k
2N3638
10k
10k
10k
2N3638
2N3638
.01μfd
22k
control voltage input
2N3565
910 μμfd.
910 μμfd
22 K
22 K
910 μμfd
4.7k
2N3566
C1
47k
22μμfd.
10k
4.7k
10k
470Ω
3.3k
150Ω
10k
2N3638
15k
A1
2N3565
3.3k
22k
.047 μfd
150Ω
+15v.
2N3565
D1
1k
470 μμfd.
22meg
B1
D1
unregulated +

Buchla Random Voltage Source (Model 165)

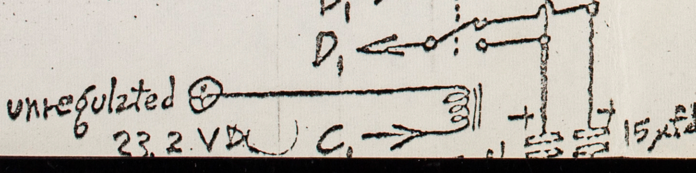

v.
A1
A2

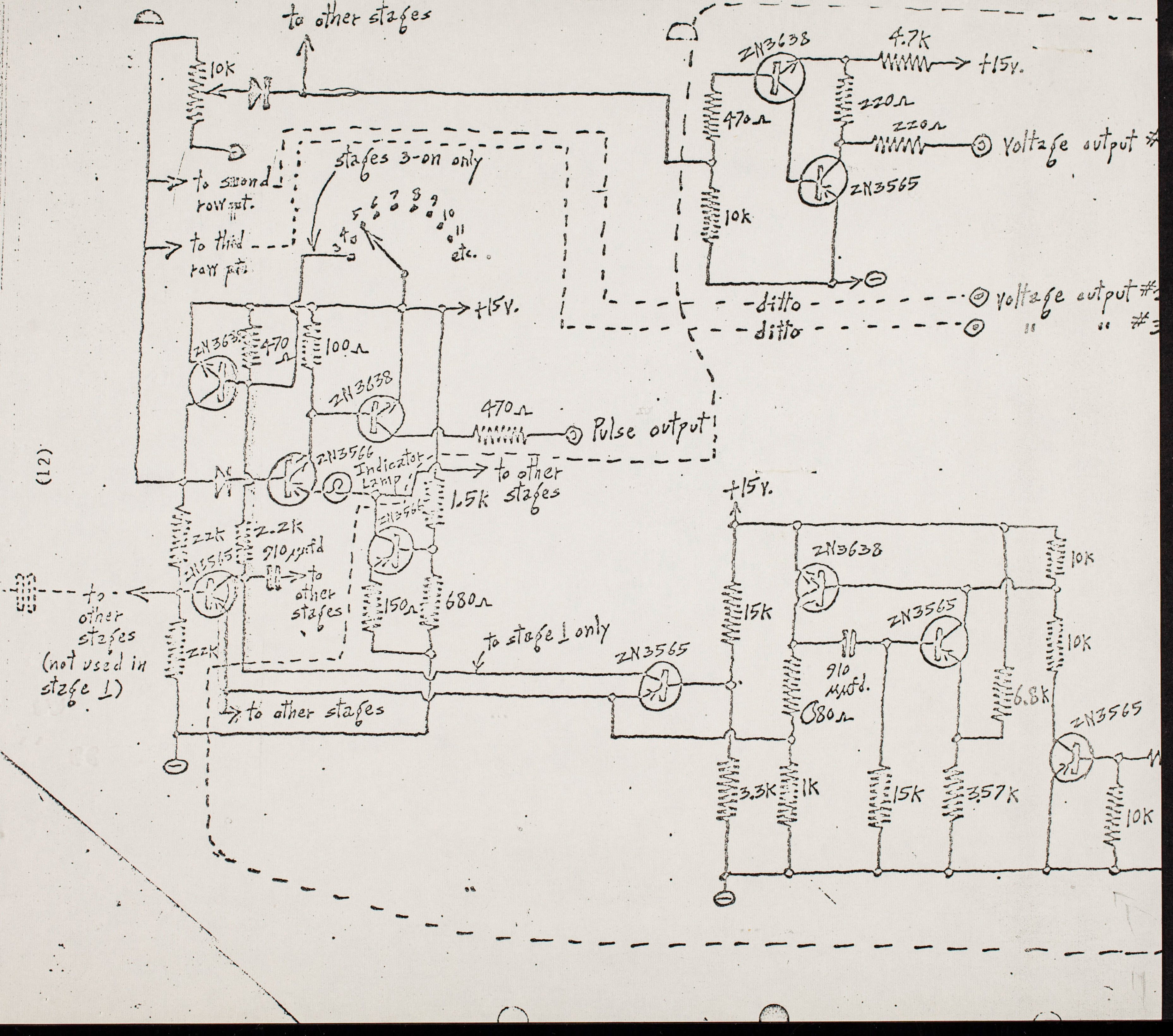

+15v.
3.3k
150Ω
2N3638
10k
100k
10k
2N3638
2N3565
15k
3.3k
2N3565
15k
68k
2N3565
100k
A1
22k
33k
47Ω
B1
.047 mfd
150Ω
3.3k
3.3k
330k
22k

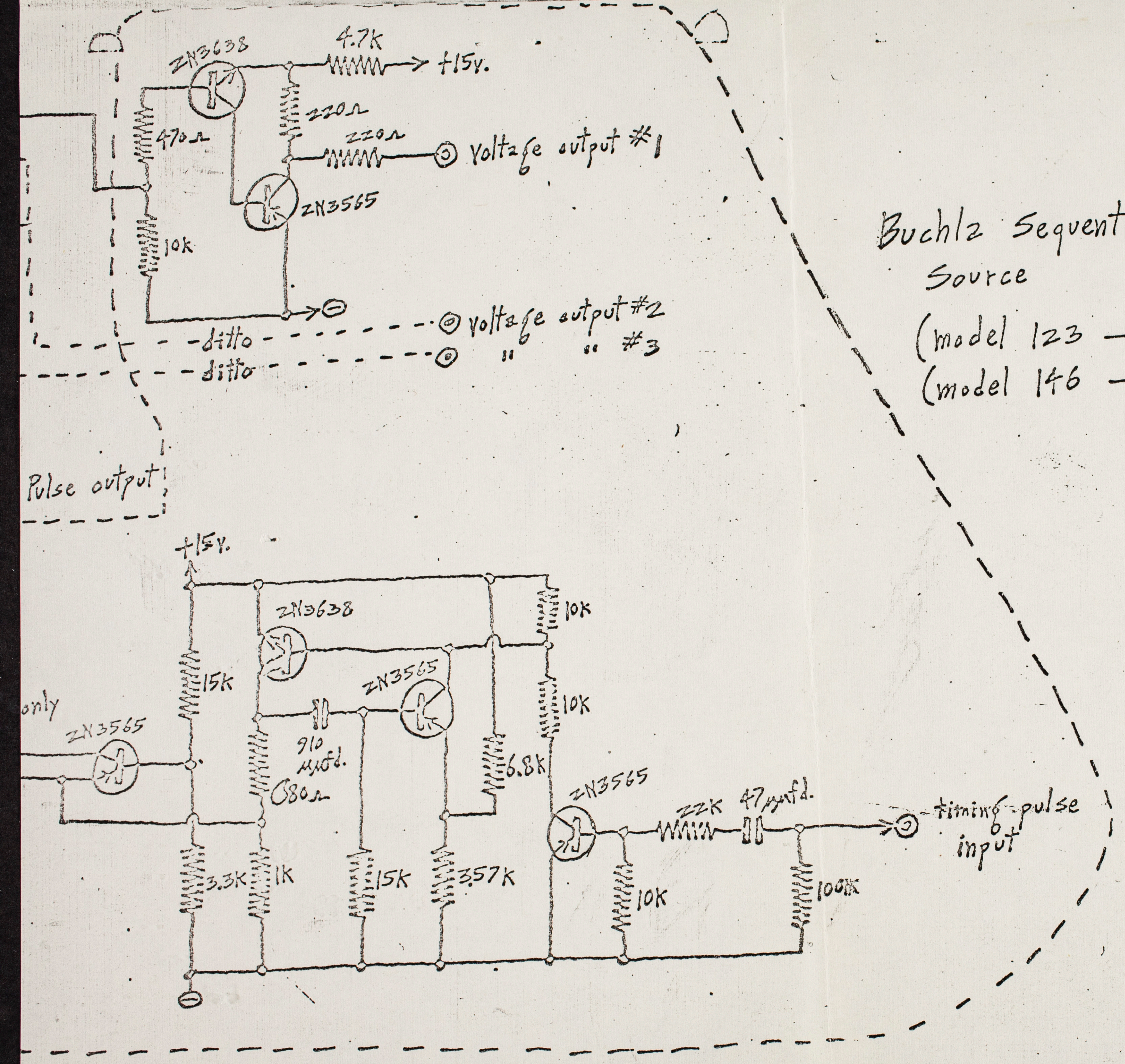

2N3565
C1
470Ω


+15v.
22meg.
1meg.
2N3565
2N3565
4.7k
3.3k
2N3638
2N3565
D1
2N3565
100k
1k
68k
220Ω
conti
voltz
outpu
(randomized
22meg
470 µfd.
470 µfd.
100k
4.7meg.
10k
2.2k

5)

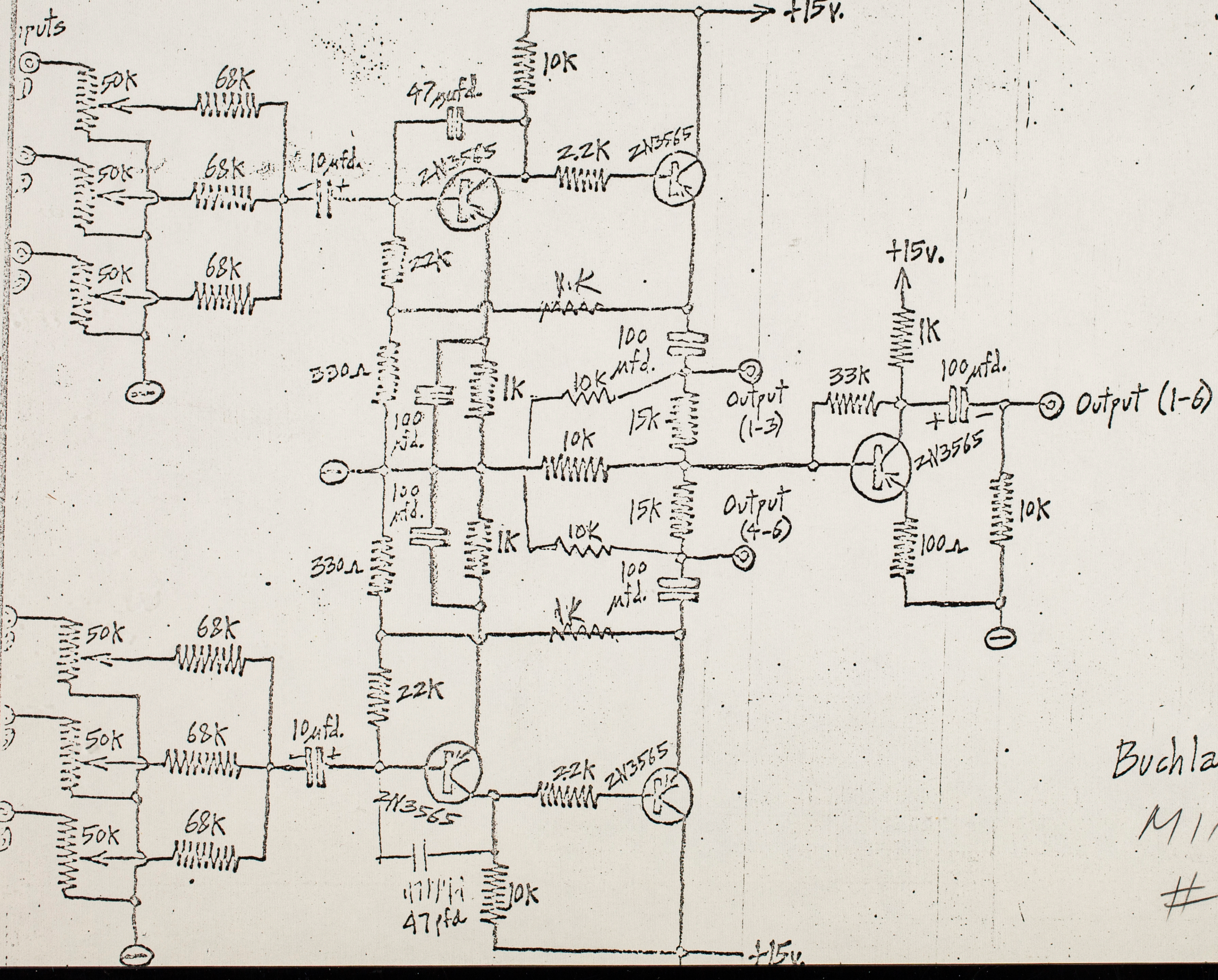

B1
D1
unregulated
23.2 VDC
C1
+
+
15µfd.


to other stages
10K
to second row pt.
to third row pts
stages 3-on only
3 4 5 6 7 8 9 10 11
etc.
ZN3638
4.7K
+15v.
470Ω
220Ω
220Ω
voltage output #
ZN3565
10K
ditto
voltage output #
ditto
" " #
+15v.
ZN3638
470Ω
100Ω
ZN3638
470Ω
Pulse output
ZN3566
Indicator Lamp
to other stages
1.5K
ZN3566
2.2K
2.2K
910 μμfd
to other stages
ZN3565
150Ω
680Ω
to other stages (not used in stage 1)
22K
to stage 1 only
ZN3565
to other stages
+15v.
15K
ZN3638
10K
ZN3565
910 μμfd.
680Ω
10K
6.8K
ZN3565
3.3K
1K
15K
3.57K
10K


2N3638
4.7k
+15v.
220Ω
470Ω
220Ω
Voltage output #1
2N3565
10k
Voltage output #2
ditto
" " #3
ditto
Pulse output
+15v.
2N3638
10k
2N3565
10K
15k
only
2N3565
910 μμfd.
680Ω
6.8k
2N3565
22K
47μμfd.
timing pulse input
3.3K
1K
15K
357K
10K
100K

Buchla Sequential Voltage Source

(model 123 - 8 stages)
(model 146 - 16 stages)

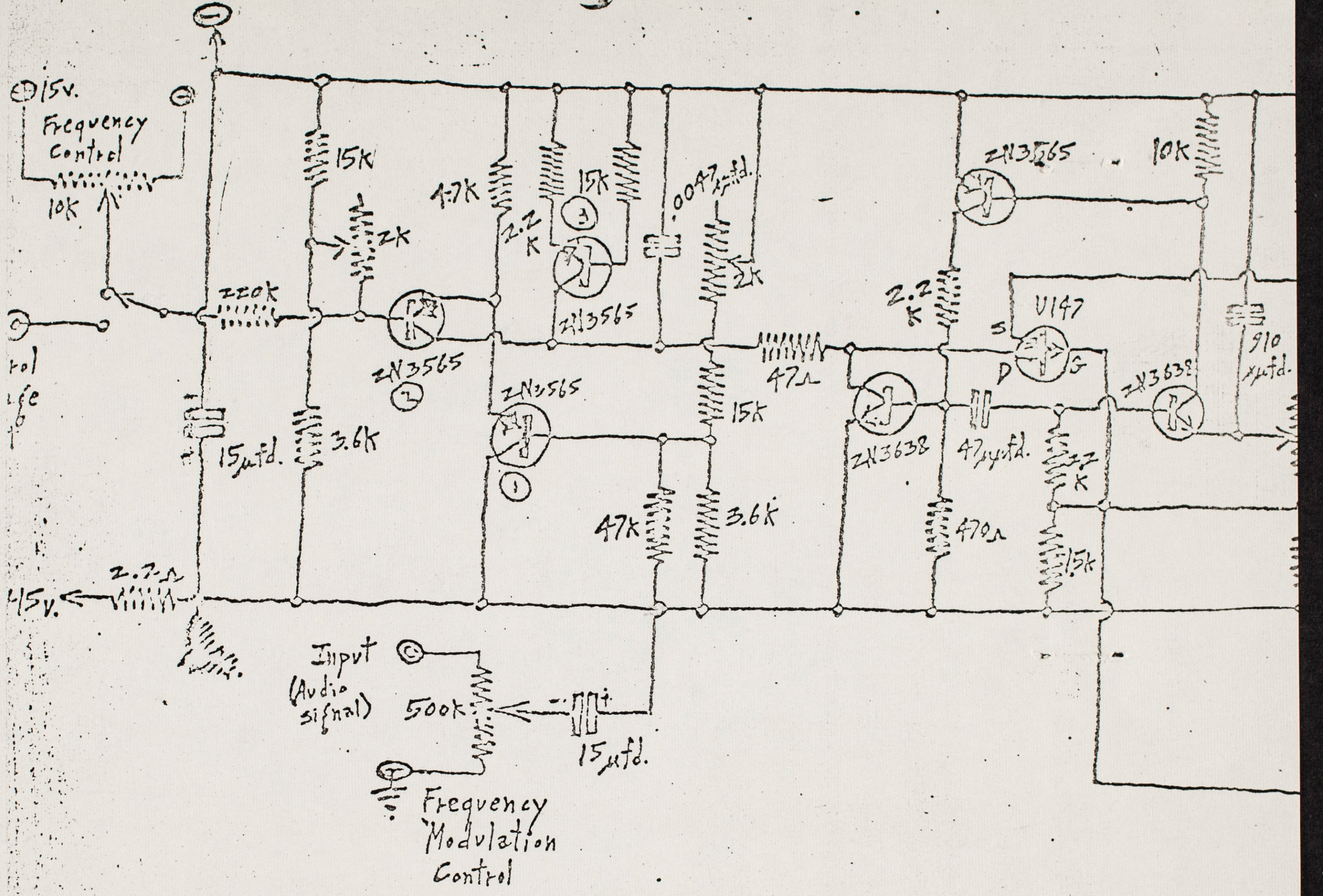


+15v.
10K
47 µfd.
puts
50K
68K
50K
68K
10 µfd.
2N3565
2.2K
2N3565
50K
68K
22K
1K
100 µfd.
330Ω
1K
10K
Output (1-3)
33K
1K
+15v.
100 µfd.
Output (1-6)
100 µfd.
15K
10K
2N3565
100 µfd.
15K
Output (4-6)
10K
1K
330Ω
100 µfd.
100Ω
10K
1K
50K
68K
22K
50K
68K
10 µfd.
22K
2N3565
50K
68K
2N3565
10K
47 pfd
+15v.

Buchla Six Chan

MIXR

#105

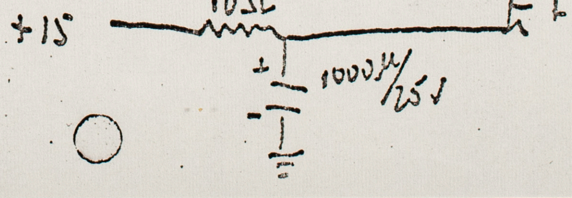

15v.
Frequency Control
10k
rol
ge
220k
15k
2k
4.7k
2.2 K
15k
③
2N3565
.0047 μfd.
2k
2N3565
②
47Ω
2N3565
①
15 μfd.
3.6K
47k
15k
3.6K
2N3565
10k
2.2 K
V147
S
D
G
2N3638
2N3638
47 μfd.
2.2 K
470Ω
15k
910 μfd.
2.2Ω
15v.
Input (Audio signal)
500k
15 μfd.
Frequency Modulation Control

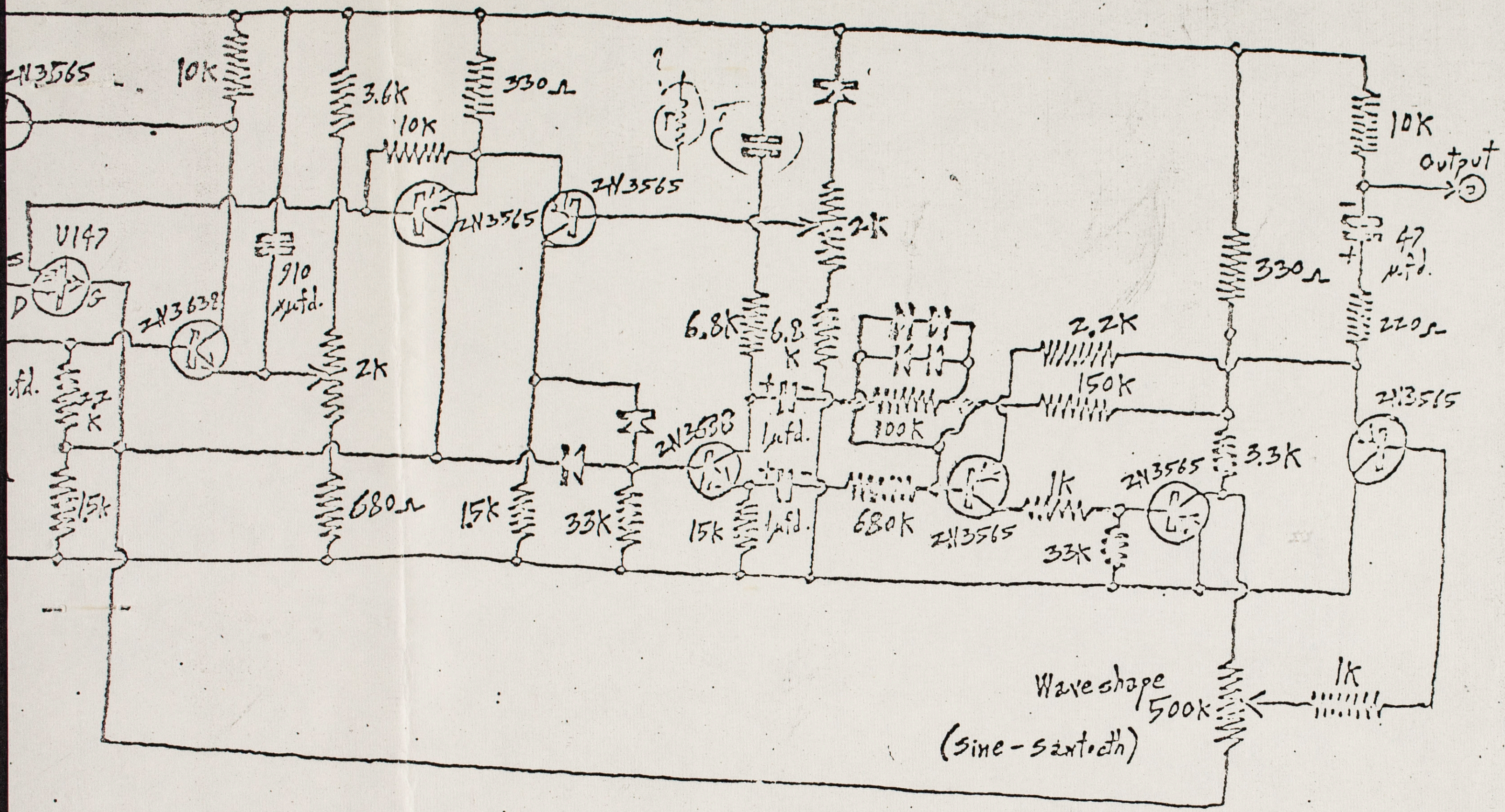
½ Buchla Dual Sine-sawtooth

V147

Instal

GNAZZO MOD ON JMC PROTOTYPES:

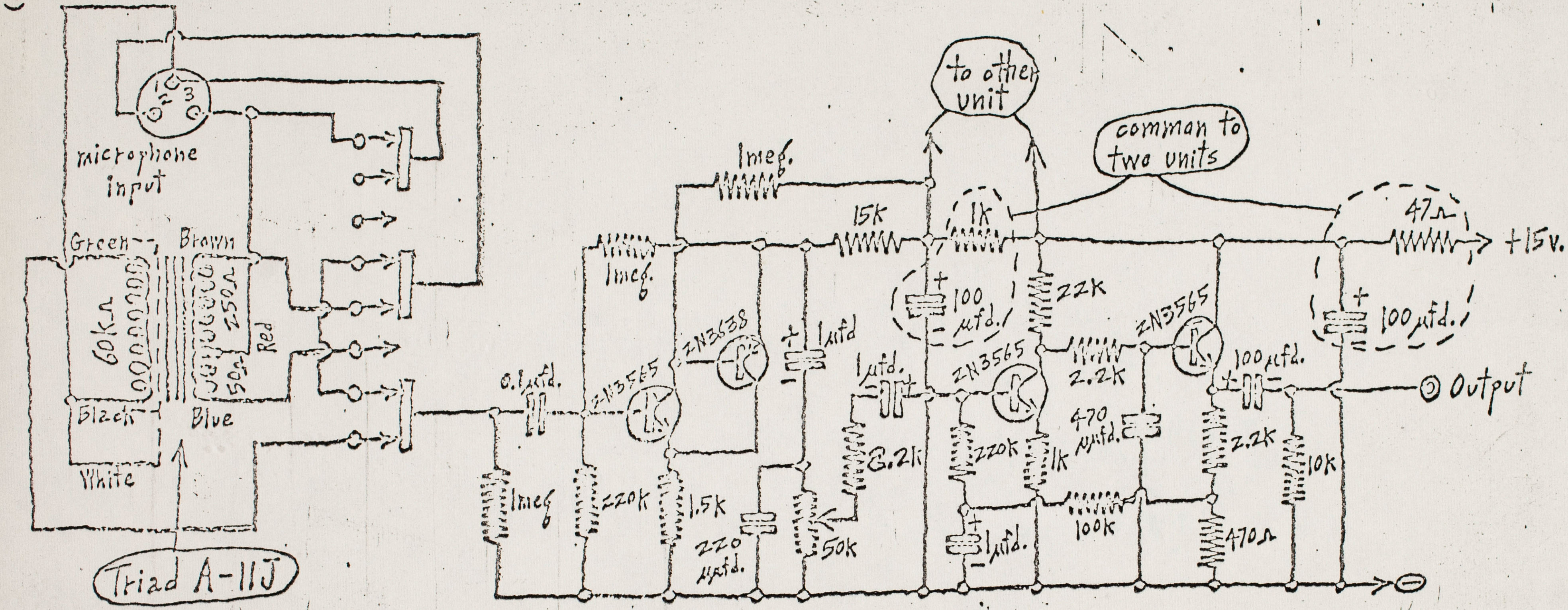

+15
10Ω
+
1000μ/25v


2N3565
10K
3.6K
330Ω
10K
V147
D
G
2N3638
910 µfd.
2K
µfd.
2.2 K
15k
2N3565
2N3565
2K
680Ω
15K
33K
2N3638
6.8K
6.8 K
1µfd.
1µfd.
15K
100K
2.2K
150K
680K
2N3565
1K
33K
2N3565
3.3K
330Ω
10K
output
47 µfd.
220Ω
2N3565
Waveshape
500K
(Sine-sawtooth)
1K

Sine-sawtooth Generator (Model 158)

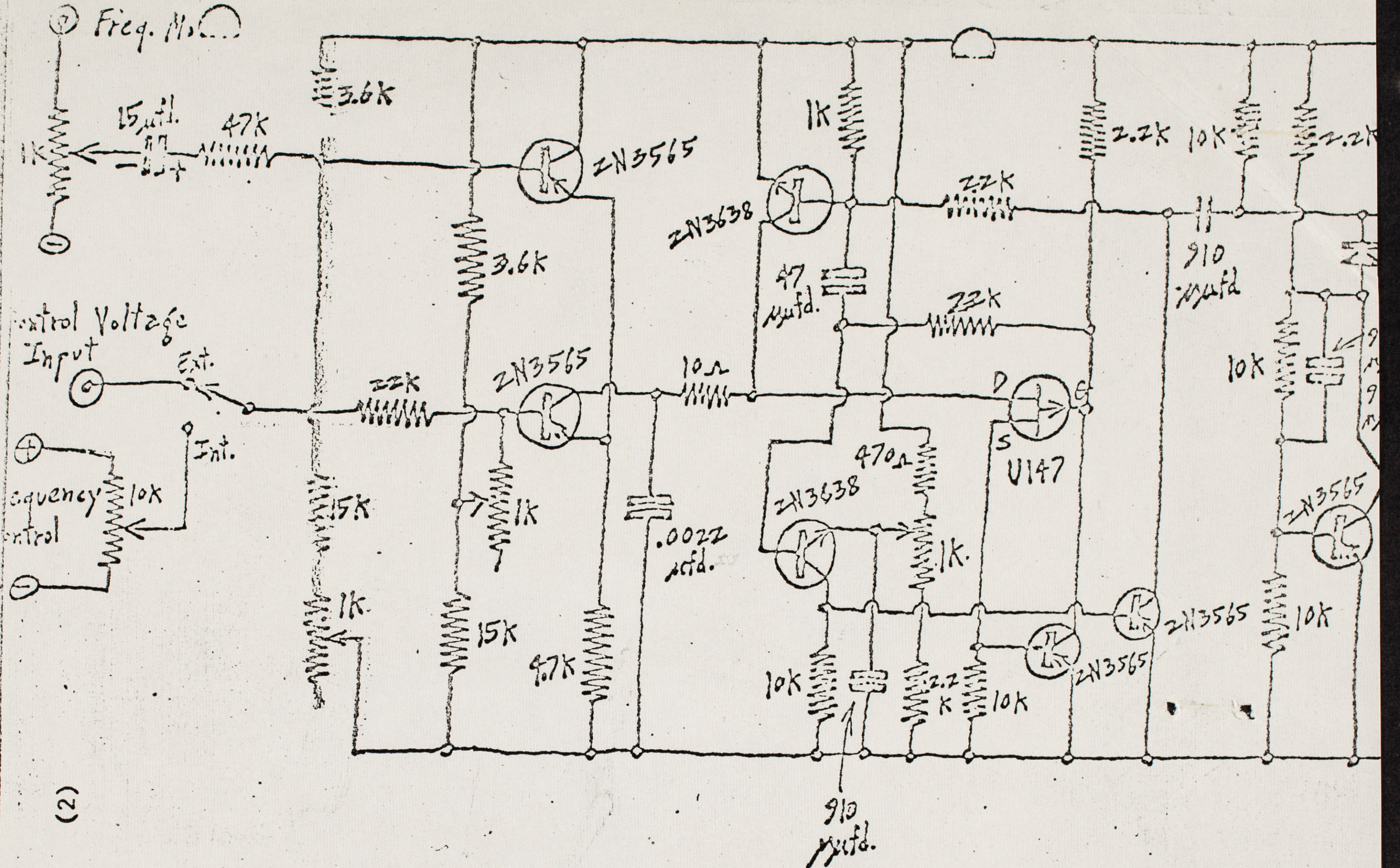
V147

Installed as viewed from top

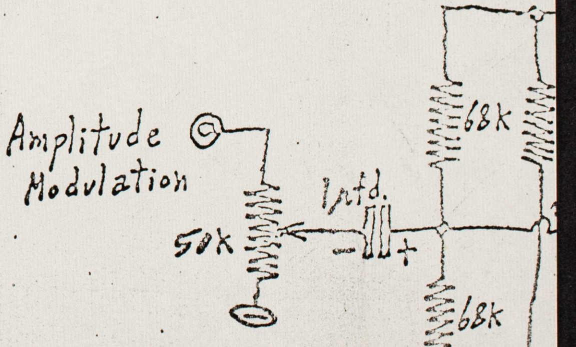

microphone input
1
2
3
Green
Brown
60kΩ
250Ω
50Ω
Red
Black
Blue
White
Triad A-11J
0.1 μfd.
1meg
2N3565
220k
2N3638
1.5k
1meg.
1meg.
15k
1μfd
220 μfd.
50k
1μfd.
8.2k
to other unit
1k
100 μfd.
command to two units
47Ω
+15v.
22k
2N3565
220k
1k
1μfd.
2.2k
470 μfd.
100k
2N3565
100 μfd.
2.2k
470Ω
10k
100 μfd.
Output

½ Buchla Dual Microphone Preamplifier (model 170)

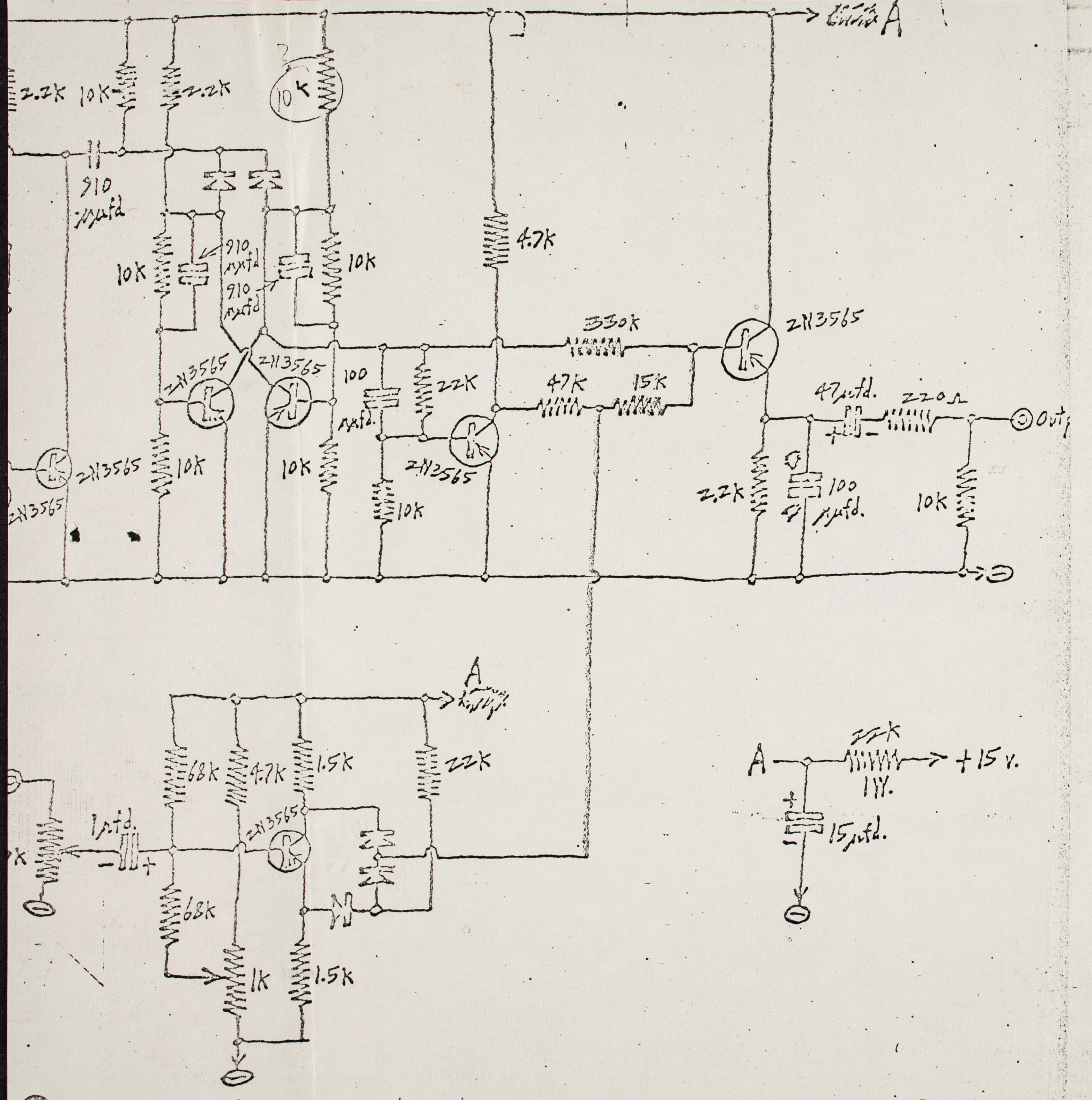
Input Impedance
① 50K
② 150-250
③ 30-50

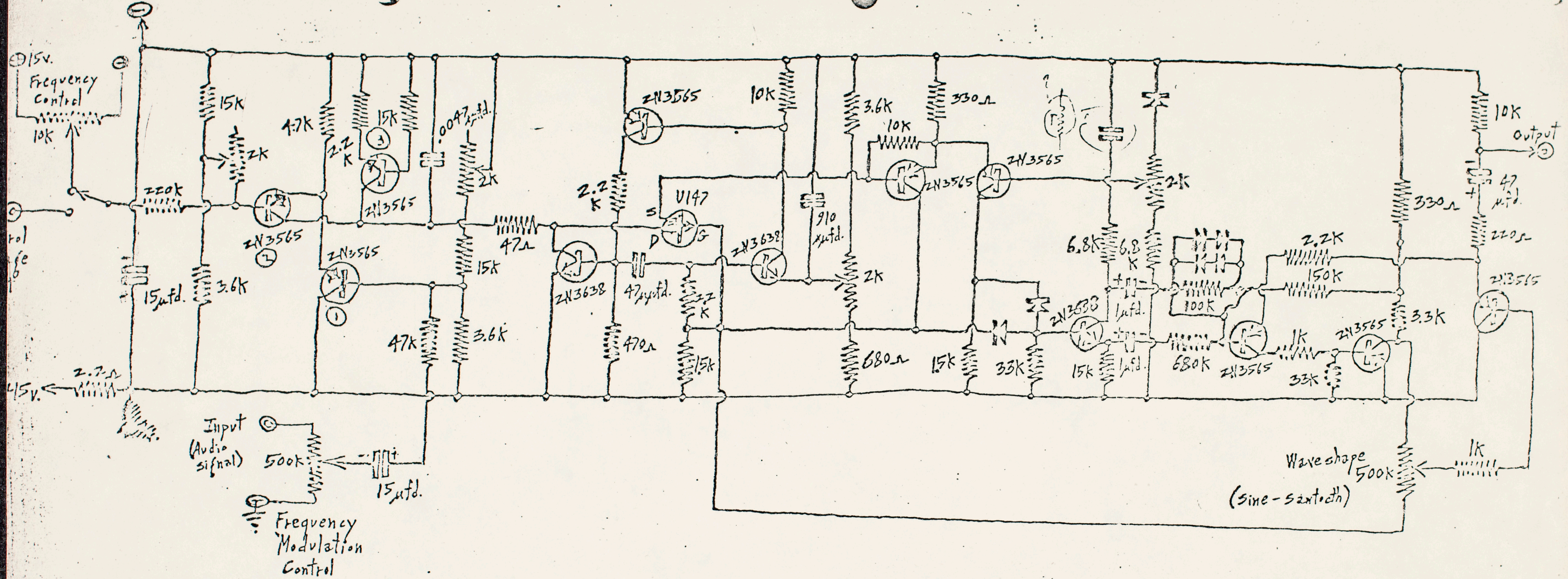

Freq. M...
1K
15 µfd.
47K
3.6K
2N3565
1K
2N3638
2.2K
10K
2.2K
22K
3.6K
47 µµfd.
22K
910 µµfd
...ntrol Voltage Input
Ext.
Int.
22K
2N3565
10Ω
D
G
S
U147
10K
...quency ...ntrol
10K
15K
1K
470Ω
2N3638
.0022 µfd.
1K
1K
15K
4.7K
2N3565
2N3565
10K
10K
2.2K
10K
10K
2N3565
10K
910 µµfd.

(2)


Amplitude Modulation
50K
1 µfd.
68K
68K

$\frac{1}{2}$ Buchla Dual Square Wave Generator (model 144)


A
2.2k
10k
2.2k
10k
910 μμfd
910 μμfd
910 μμfd
10k
10k
4.7k
330k
2N3565
2N3565
2N3565
2N3565
2N3565
2N3565
100 μμfd.
22K
47k
15k
47μfd.
220Ω
Out
10k
2.2k
10k
100 μμfd.
10k
10k
A
68k
4.7k
1.5k
22k
2N3565
1μfd.
68k
1k
1.5k
A
22k
1W.
+15 v.
15μfd.



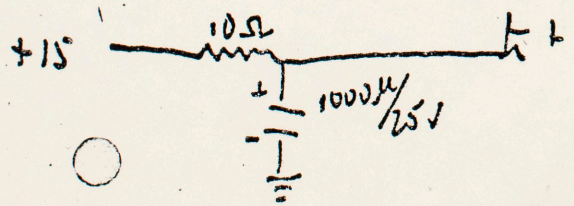
−
+15v.
Frequency control
10k
220k
15k
2k
3.6k
15μfd.
ZN3565
4.7k
2.2 k
15k
ZN3565
.0047 μfd.
2k
ZN3565
15k
47k
3.6k
47Ω
2.2 k
ZN3565
ZN3638
470Ω
47μfd.
V147
S
D
G
2.2 k
15k
ZN3638
10k
910 μμfd.
3.6k
10k
330Ω
ZN3565
ZN3565
2k
680Ω
15k
33k
2k
6.8k
6.8 k
1μfd.
1μfd.
ZN3638
15k
100k
680k
2.2k
150k
ZN3565
1k
33k
ZN3565
3.3k
330Ω
10k
output
47 μfd.
220Ω
ZN3565
-15v.
2.2Ω
Input (Audio signal)
500k
15μfd.
Frequency Modulation Control
Waveshape 500k
(Sine-sawtooth)
1k

½ Buchla Dual Sine-sawtooth Generator (Model 158)

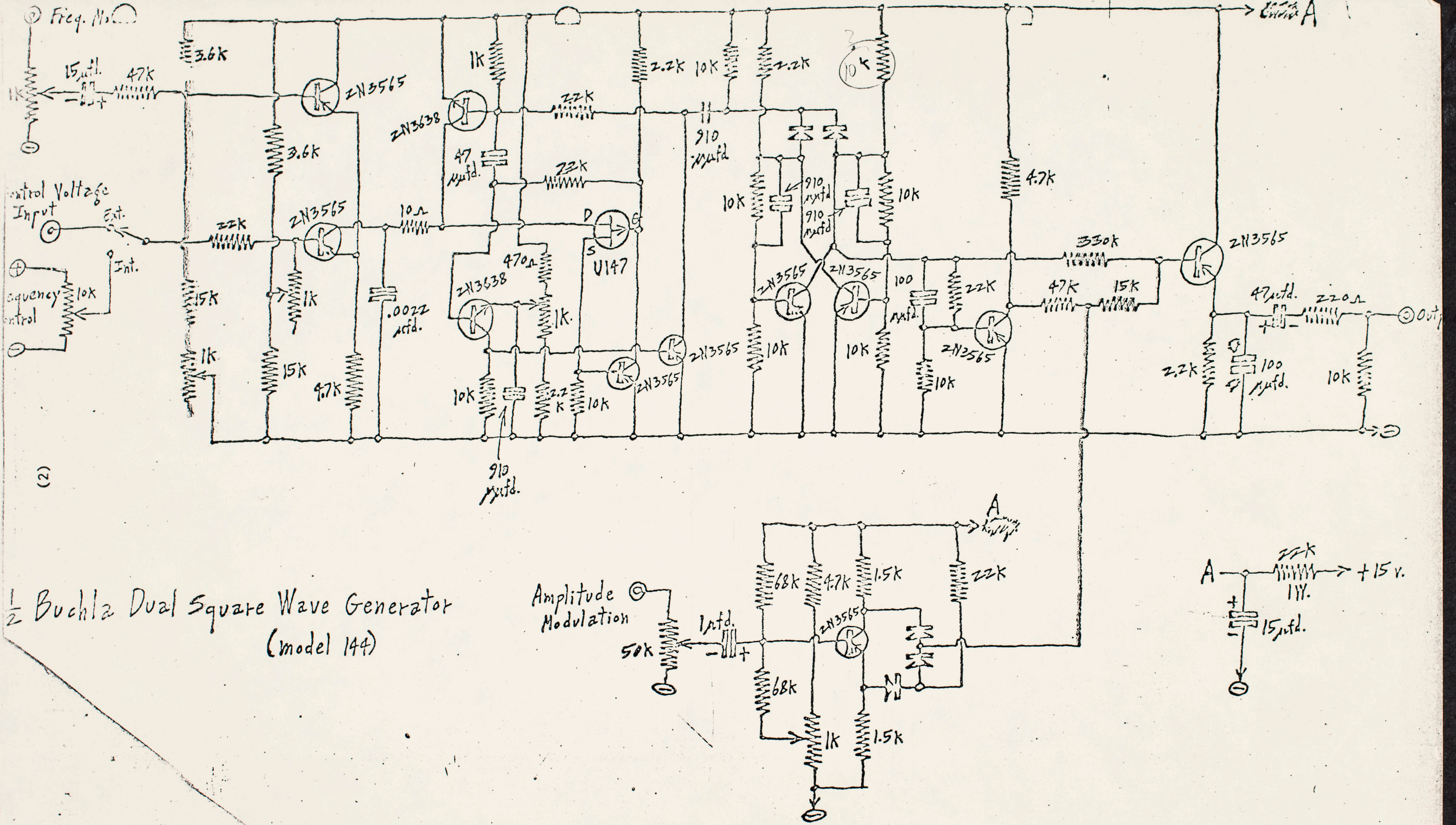
V147

Installed as viewed from top

GNAZZO MOD ON TMC PROTOTYPES:

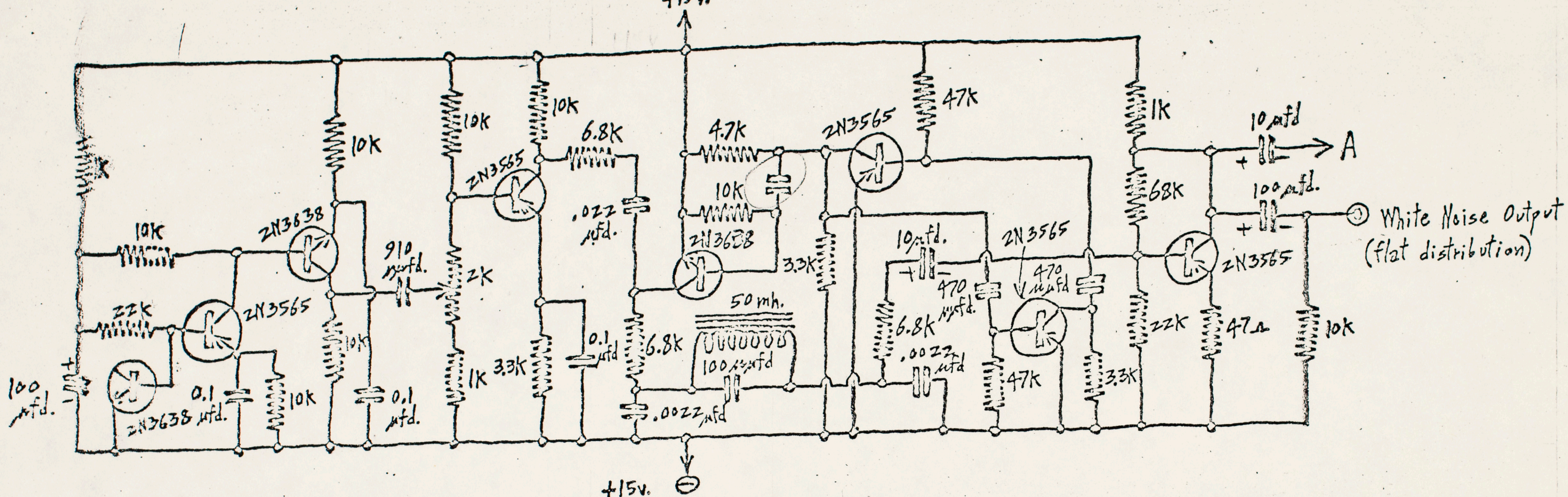


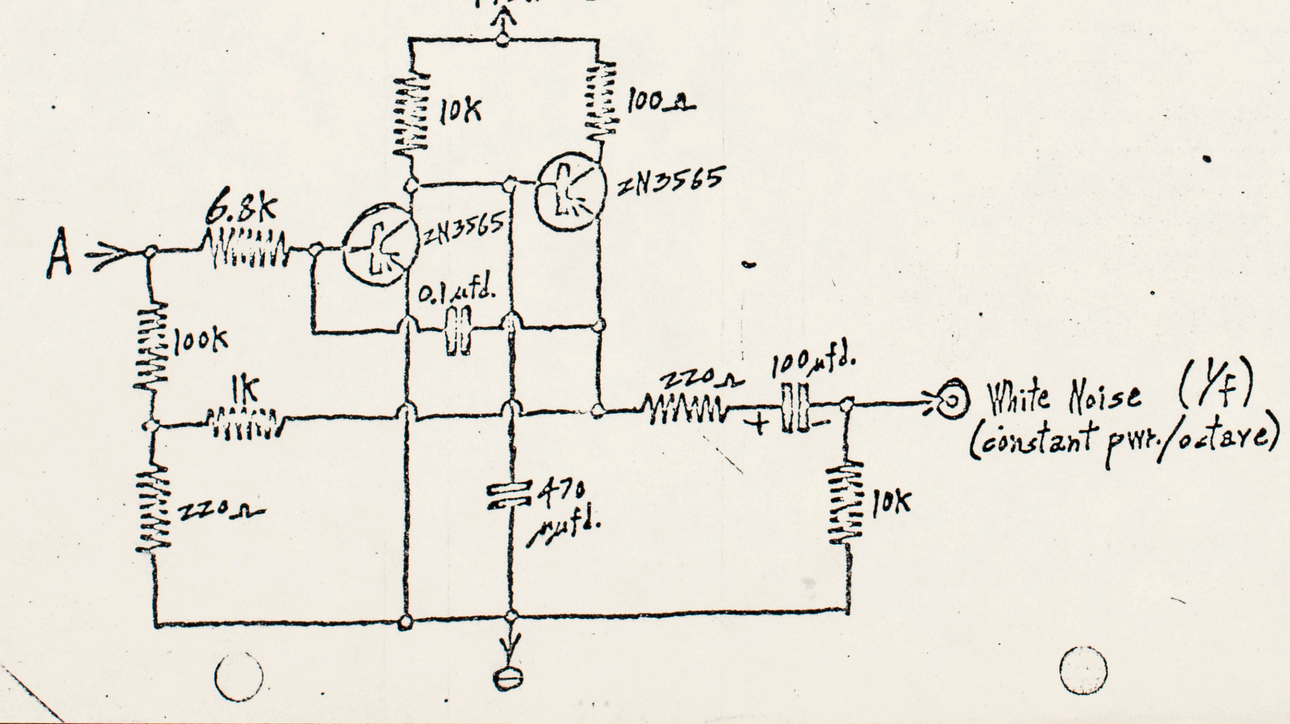
+15
10Ω
+
1000μ/25V


Freq. Mo...
1K
15µfd.
47K
3.6K
2N3565
1K
2N3638
22K
2.2K
10K
910 µµfd
2.2K
10K
A
47 µµfd.
22K
4.7K
Control Voltage Input
Ext.
Int.
22K
2N3565
10Ω
D
G
S
U147
330K
2N3565
Frequency Control
10K
15K
1K
470Ω
2N3638
1K
.0022 µfd.
910 µµfd
10K
100 µµfd.
22K
47K
15K
47µfd.
220Ω
Out
1K
15K
4.7K
10K
2.2K
10K
2N3565
2N3565
2N3565
2N3565
2N3565
10K
10K
10K
2.2K
100 µµfd.
10K
910 µµfd.
A
68K
4.7K
1.5K
22K
Amplitude Modulation
2N3565
1µfd.
50K
68K
1K
1.5K
A
22K
1W.
+15 v.
15µfd.

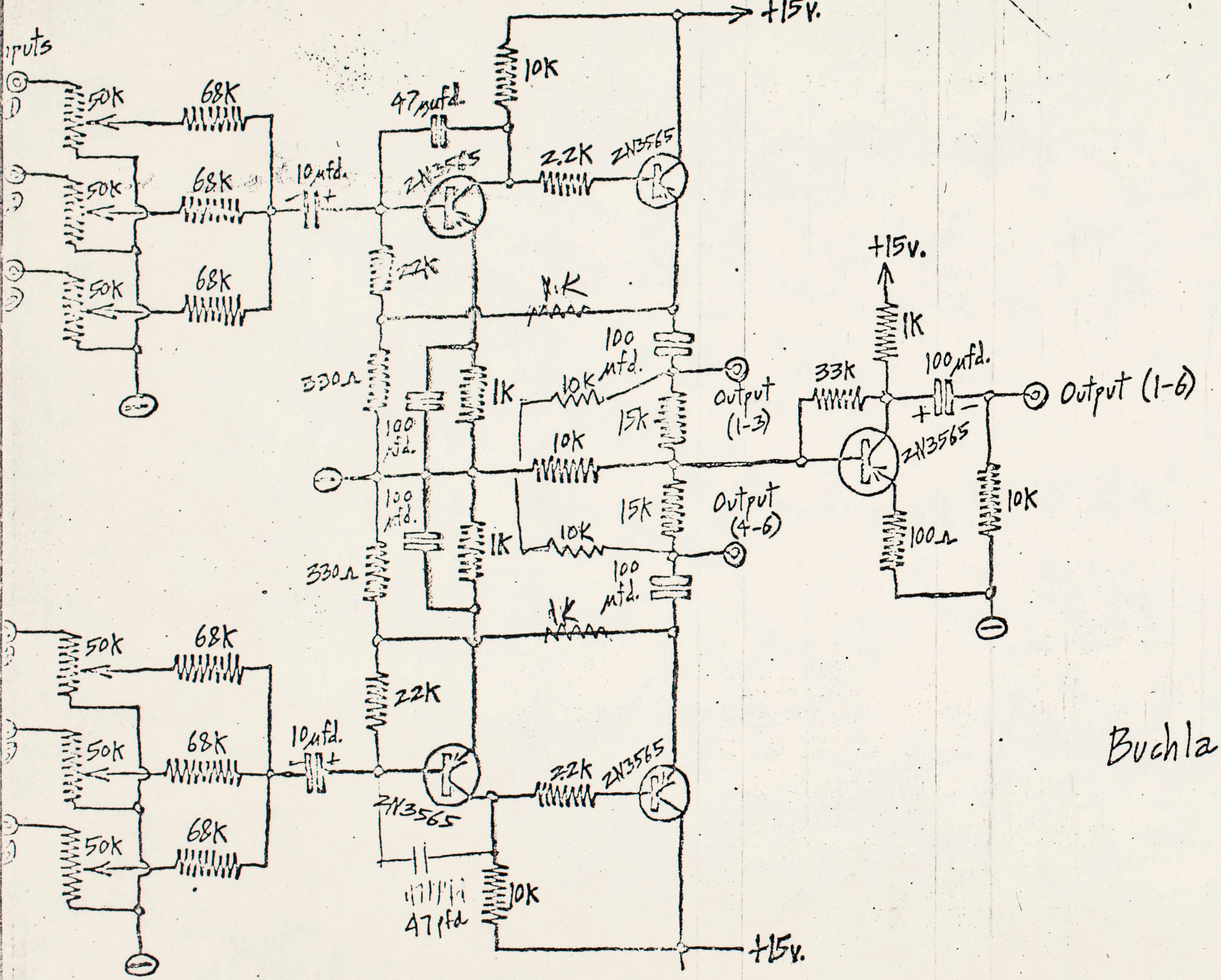
(2)

½ Buchla Dual Square Wave Generator
(model 144)

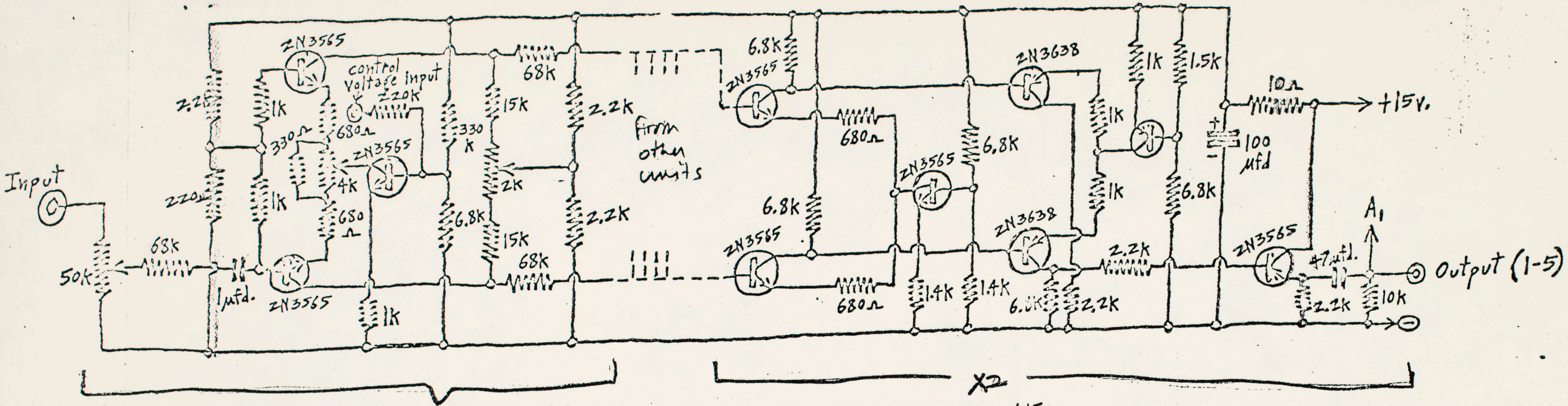

+15v.
10K
10K
10K
6.8K
2N3565
10K
2N3638
910 μμfd.
2K
22K
2N3565
100 μfd.
0.1 μfd.
10K
10K
0.1 μfd.
1K
3.3K
.022 μfd.
0.1 μfd
2N3638
0.1 μfd.
4.7K
10K
2N3638
6.8K
50 mh.
100 μμfd
.0022 μfd
3.3K
2N3565
47K
10 μfd.
6.8K
470 μμfd.
.0022 μfd
2N3565
470 μμfd
47K
3.3K
1K
68K
22K
10 μfd
A
100 μfd.
2N3565
47 Ω
10K
White Noise Output
(flat distribution)


+15v.
10K
100 Ω
2N3565
A
6.8K
2N3565
0.1 μfd.
100K
1K
220 Ω
100 μfd.
White Noise (1/f)
(constant pwr./octave)
220 Ω
470 μμfd.
10K

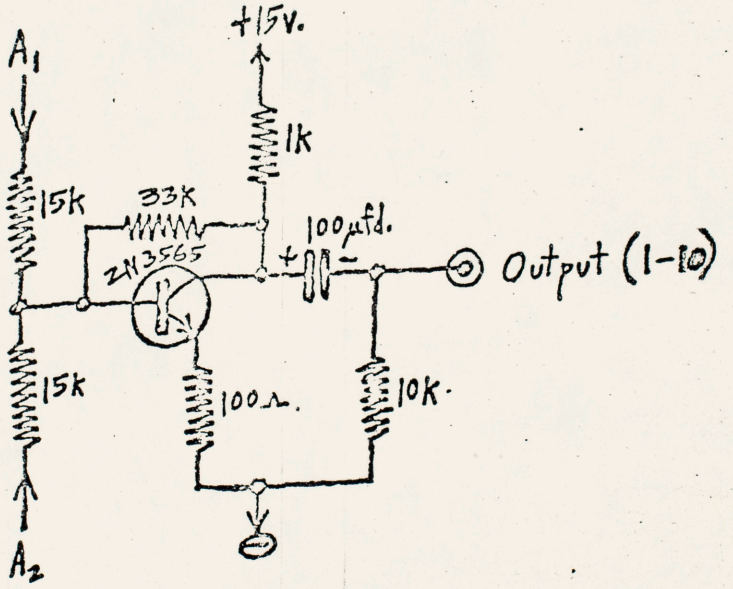
Buchla White Noise Generator
(Model 160)

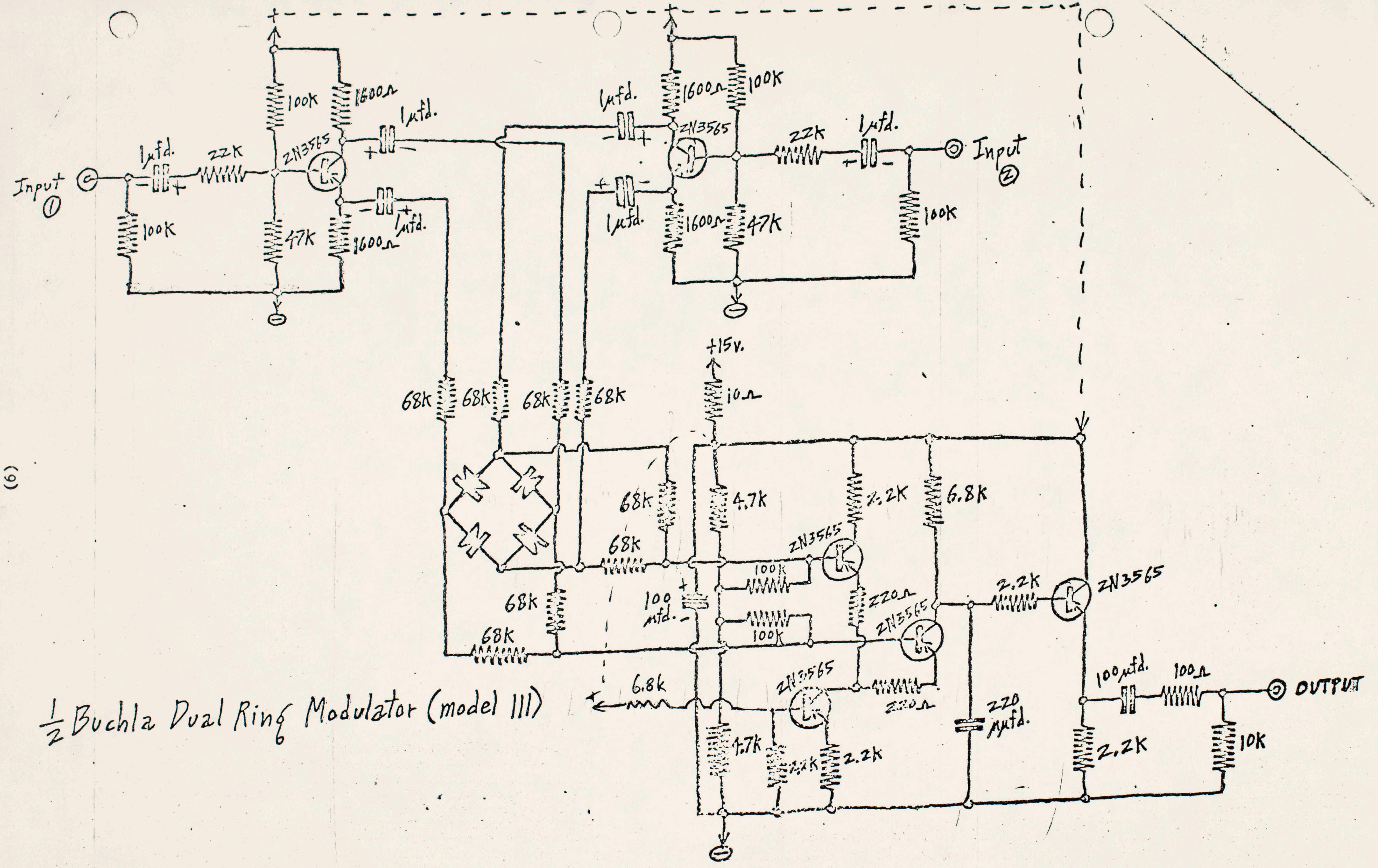

puts
50K
68K
10 mfd.
47 mfd.
10K
2.2K
2N3565
+15v.
22K
1K
330Ω
100 mfd.
15K
Output (1-3)
Output (4-6)
33K
100 mfd.
Output (1-6)
100Ω
47 pfd
+15v.

Buchla Six Channel Mixer (model 106)

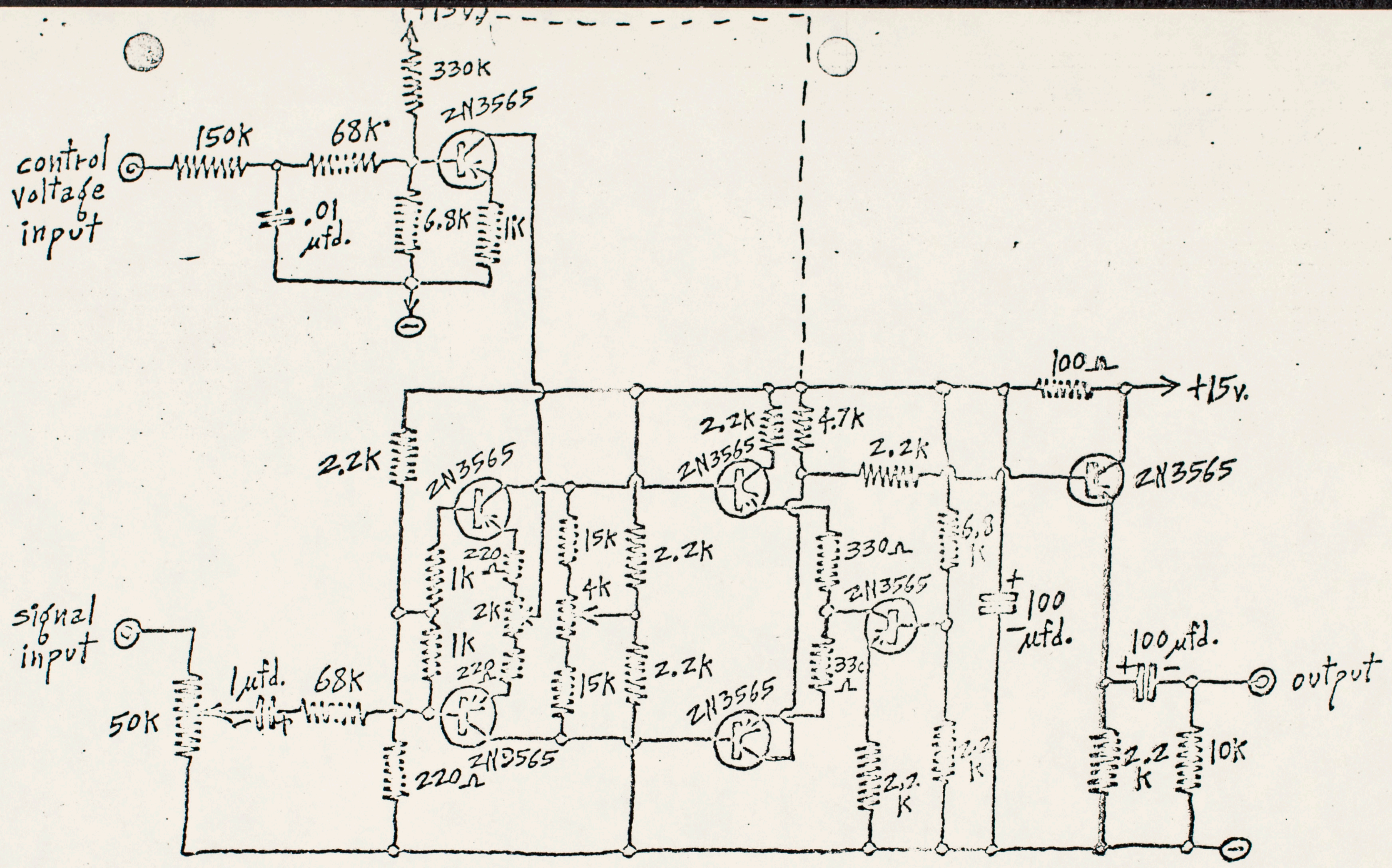

Input
50k
68k
2.2k
220Ω
1μfd.
2N3565
1k
330Ω
680Ω
4k
680Ω
control voltage input
220k
2N3565
2N3565
1k
330k
15k
2k
6.8k
15k
68k
68k
2.2k
2.2k
from other units
6.8k
2N3565
680Ω
6.8k
2N3565
2N3565
680Ω
6.8k
1.4k
1.4k
2N3638
2N3638
1k
1k
1k
1.5k
6.8k
6.8k
2.2k
2.2k
10Ω
+15v.
100 μfd
2N3565
47μfd.
2.2k
10k
A1
Output (1-5)
X2
X10

Buchla Voltage-controlled Mixer (10 channels)(model 107)

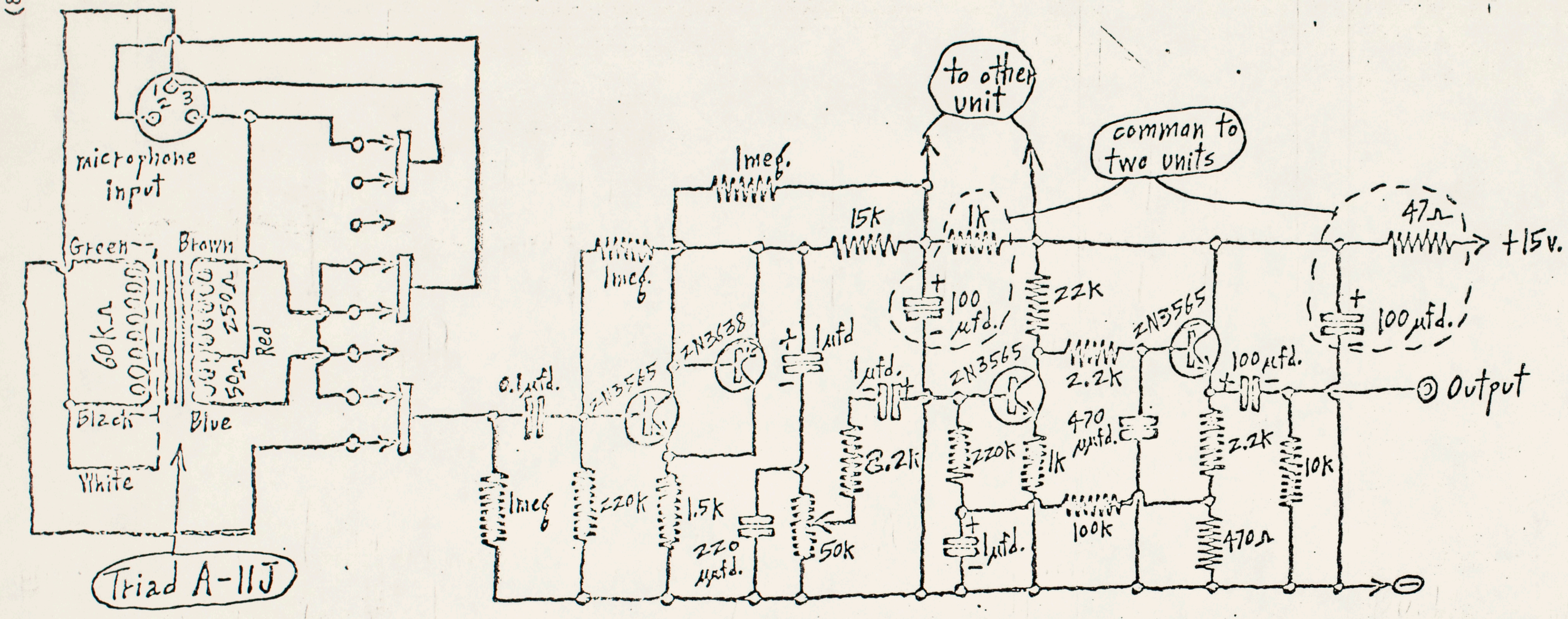

A1
+15v.
1k
15k
33k
2N3565
100μfd.
Output (1-10)
15k
100Ω
10K
A2


Input ①
1µfd.
22K
100K
47K
2N3565
1600Ω
1µfd.
1µfd.
Input ②
100K
47K
1600Ω
22K
1µfd.
100K
68K
68K
68K
68K
+15v.
10Ω
68K
4.7K
2.2K
6.8K
2N3565
68K
100K
68K
100 µfd.
220Ω
100K
2N3565
2.2K
2N3565
68K
6.8K
2N3565
220Ω
4.7K
2.2K
2.2K
220 µµfd.
100µfd.
100Ω
OUTPUT
2.2K
10K

½ Buchla Dual Ring Modulator (model III)


(+15v.)
330K
2N3565
control voltage input
150K
68K
.01 μfd.
6.8K
1K
100Ω
+15v.
2.2K
2N3565
2.2K
4.7K
2N3565
2.2K
2N3565
220Ω
1K
2K
1K
220Ω
15K
2.2K
4K
15K
2.2K
330Ω
2N3565
6.8K
100 μfd.
100μfd.
signal input
1μfd.
68K
50K
output
2N3565
330Ω
220Ω
2N3565
2.2K
2.2K
2.2K
10K

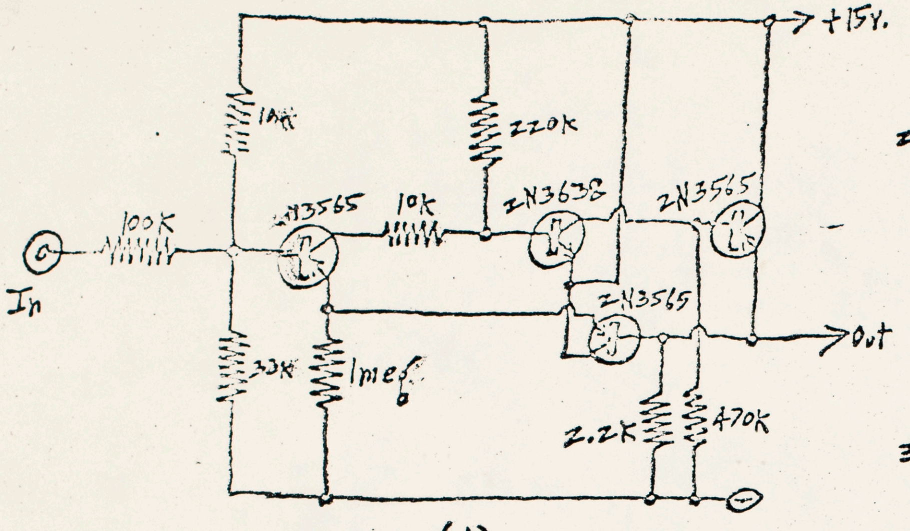
½ Buchla Dual Voltage-controlled Gate (model 110)


1
2
3
microphone input
Green
Brown
60kΩ
250Ω
50Ω
Red
Black
Blue
White
Triad A-11J
to other unit
comman to two units
1meg.
1meg.
15k
1k
47Ω
+15v.
100 µfd.
100 µfd.
22k
2N3638
2N3565
2N3565
2N3565
1µfd
1µfd.
1µfd.
0.1µfd.
1meg
220k
1.5k
220 µfd.
50k
2.2k
2.2k
2.2k
220k
1k
470 µfd.
100k
100µfd.
470Ω
10k
Output

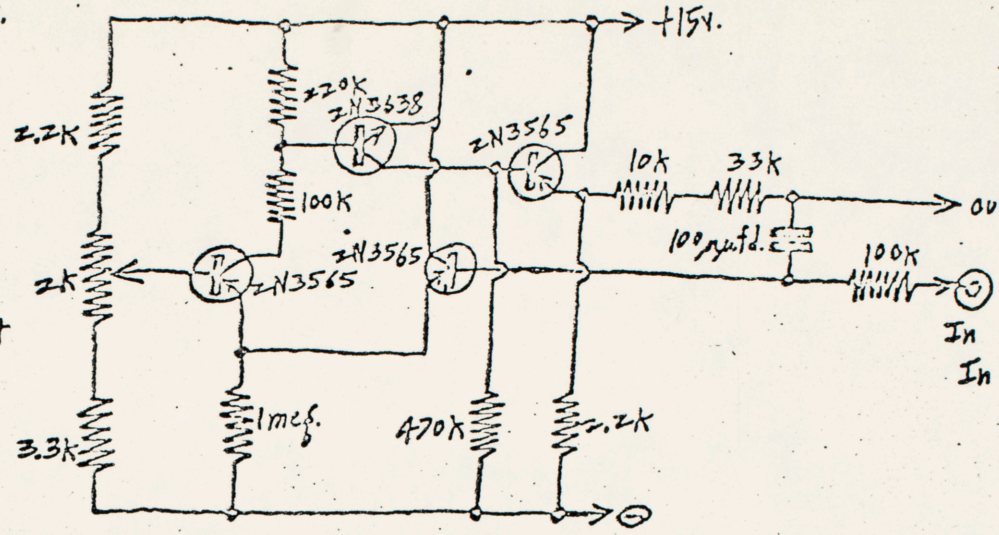
Input Impedance

① 50K
② 150-250
③ 30-50

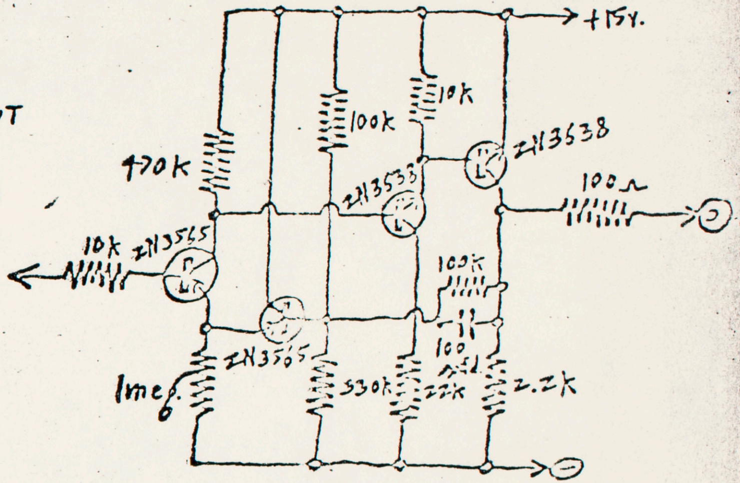
$\frac{1}{2}$ Buchla Dual Microphone Preamplifier (model 170)


+15v.
1K
220k
100K
In
2N3565
10k
2N3638
2N3565
2N3565
33K
1meg.
2.2K
470K
Out

(A)

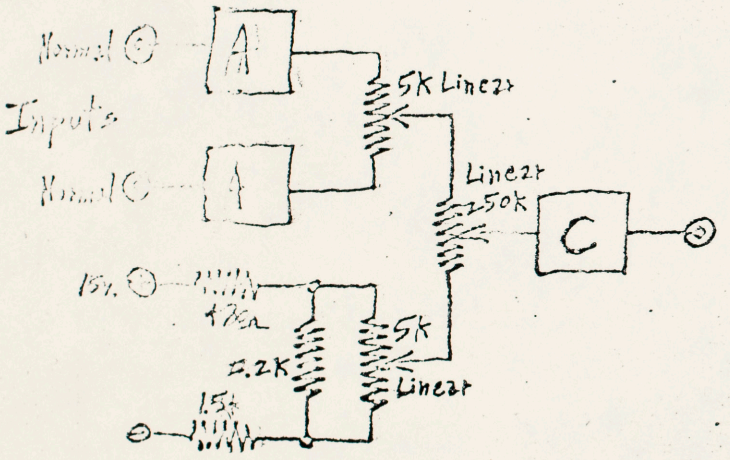

+15v.
2.2K
220K
2N3638
2N3565
10k
33k
OUT
100K
2k
2N3565
2N3565
100 μμfd.
100K
In
1meg.
3.3K
470K
2.2K

(B)

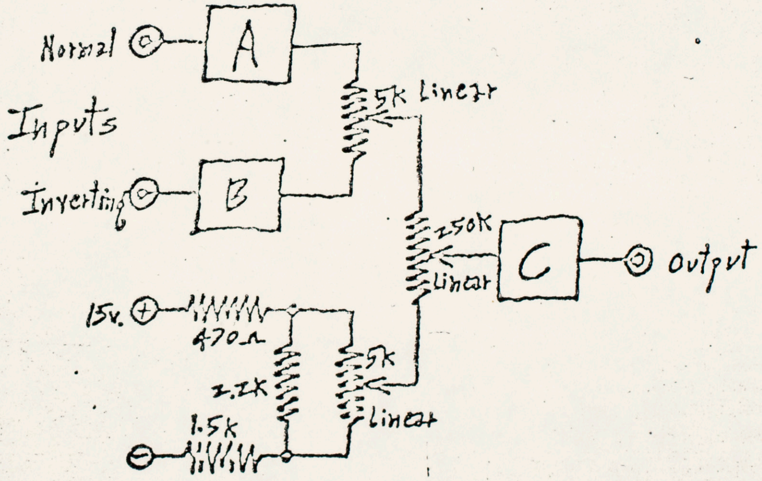

+15v.
100k
10k
470k
2N3638
2N3565
100 Ω
10k
2N3565
In
100k
2N3565
100 μμfd
1meg.
330k
22k
2.2k

(C)

(9)

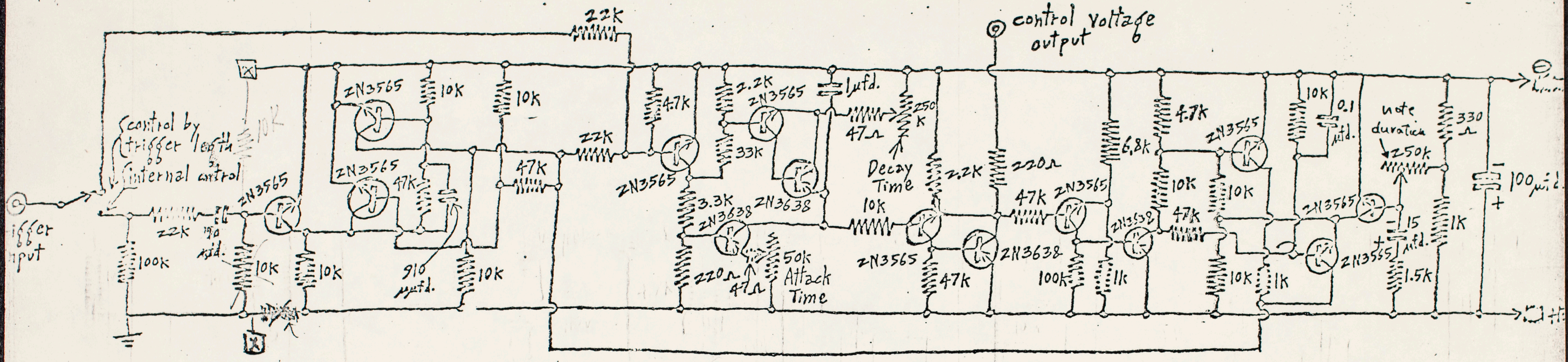

Normal
A
5K Linear
Inputs
Normal
A
Linear
250k
C
15v.
470Ω
5K
2.2K
Linear
1.5k

Left half


Normal
A
5k Linear
Inputs
Inverting
B
250K
Linear
C
output
15v.
470Ω
5k
2.2K
Linear
1.5k

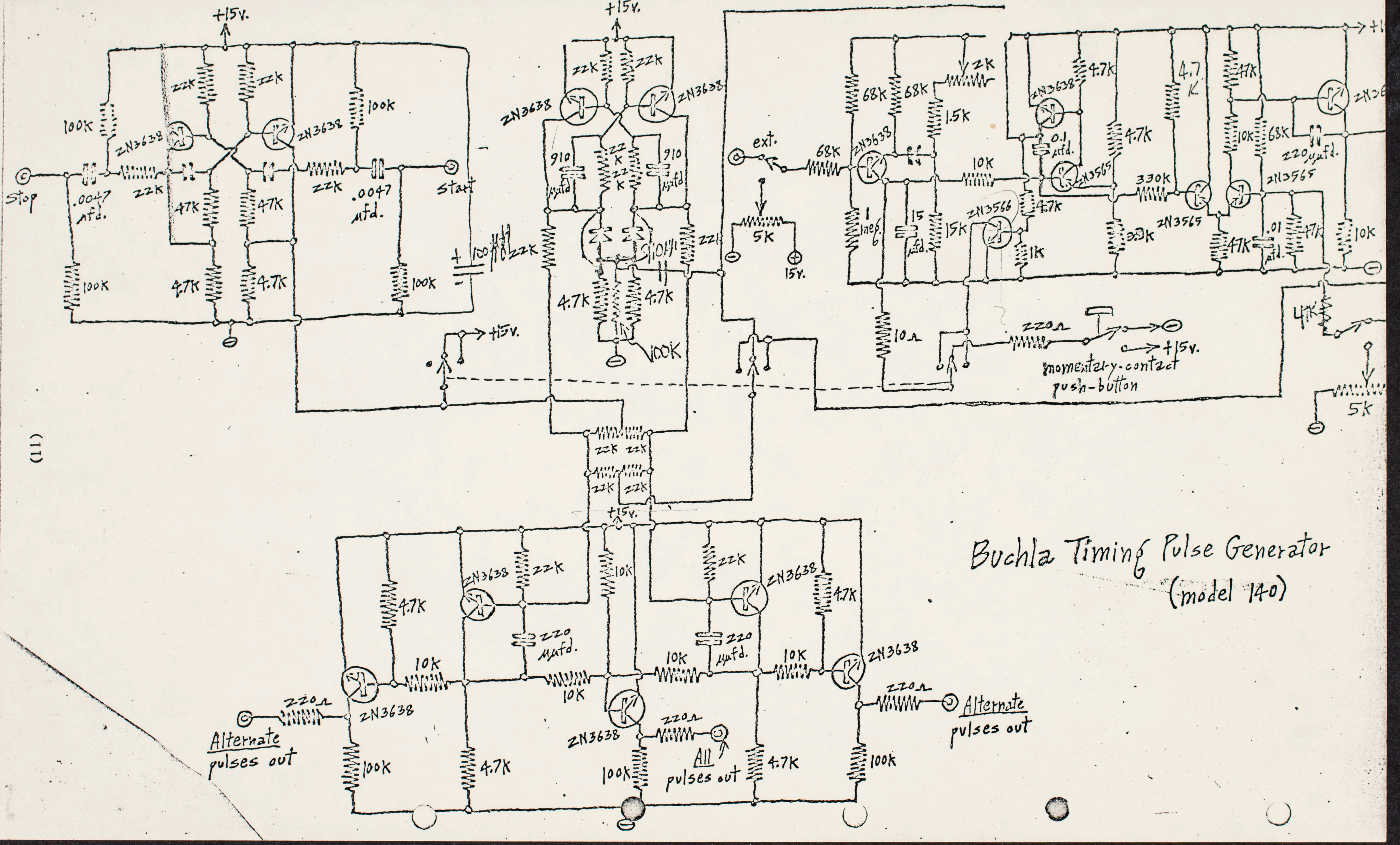
Right half

Buchla Control Voltage Processor (model 156)

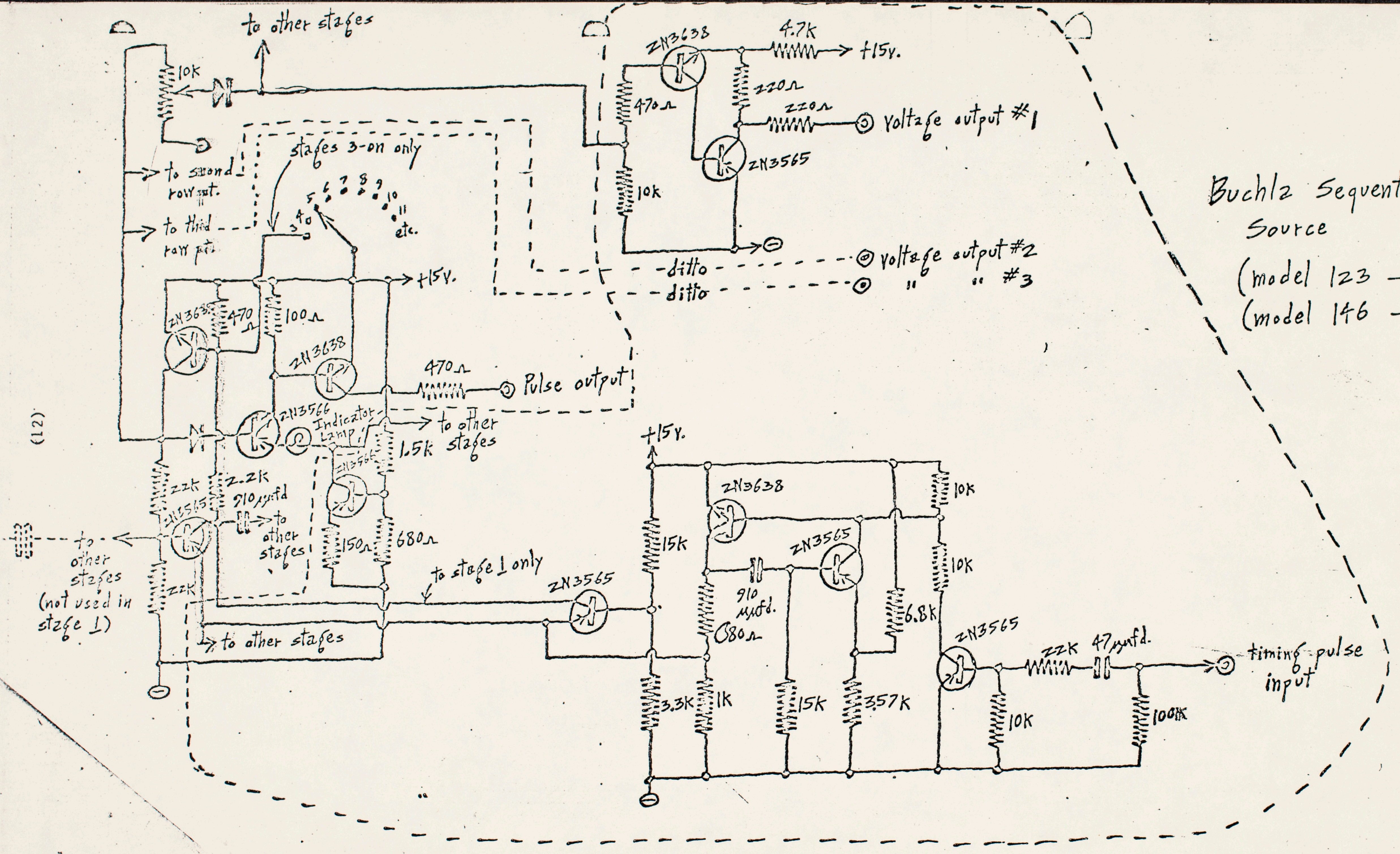

22K
control voltage output
trigger input
control by trigger length or internal control
10K
22K
.1 µfd.
2N3565
100K
10K
10K
2N3565
10K
2N3565
47K
910 µµfd.
10K
10K
22K
47K
2N3565
4.7K
2.2K
2N3565
33K
2N3638
3.3K
2N3638
220Ω
47Ω
50K
Attack Time
1µfd.
47Ω
250 K
Decay Time
2.2K
10K
2N3565
47K
2N3638
220Ω
47K
2N3565
100K
1K
6.8K
2N3638
4.7K
10K
47K
10K
2N3565
10K
10K
1K
10K
0.1 µfd.
2N3565
2N3555
note duration
250K
15 µfd.
1.5K
330 Ω
1K
100 µfd.

½ Buchla Dual Attack Generator (model 180)

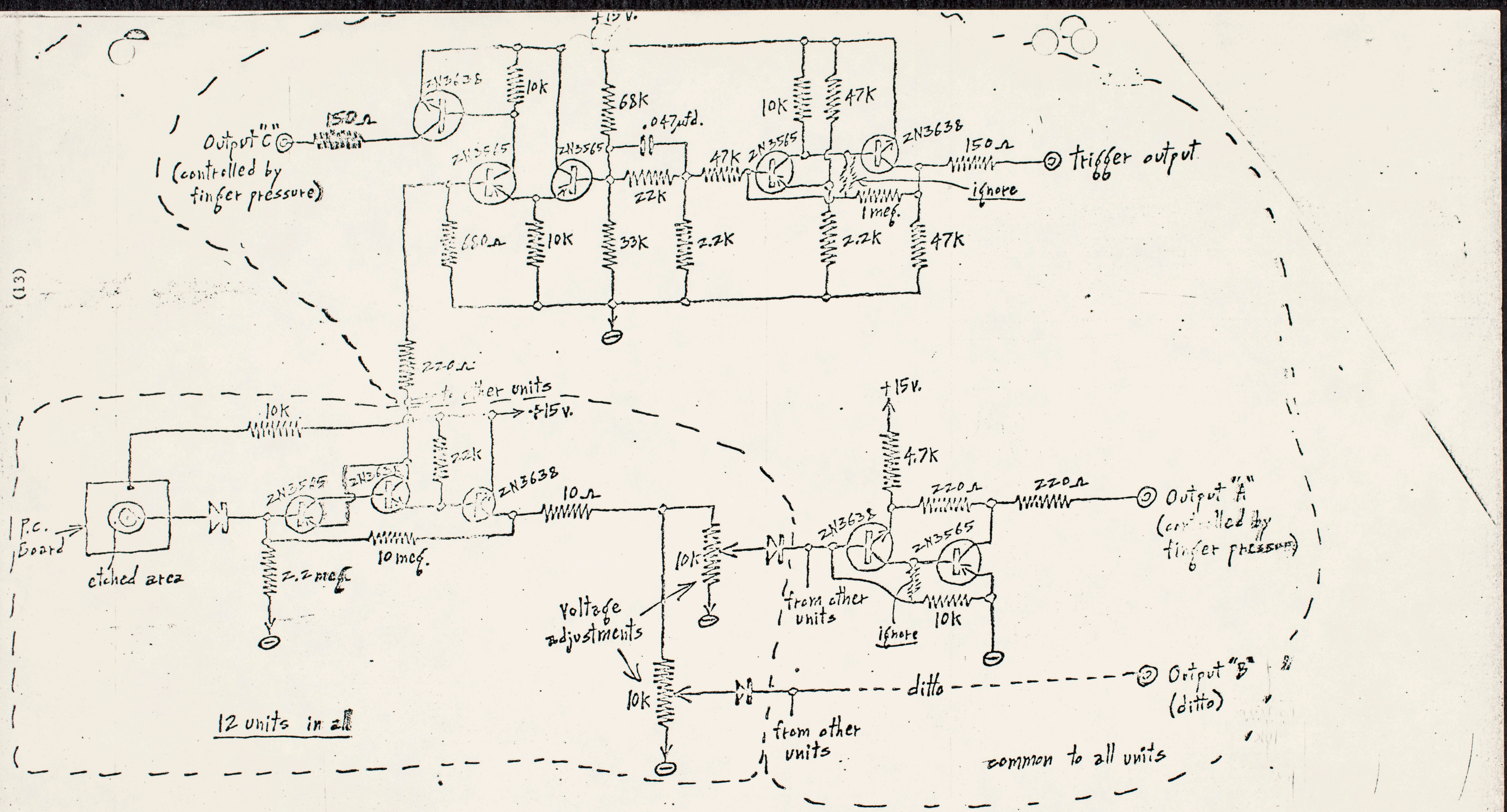
☒ Note error in running resistor to +15. Should be run to ground.


+15v.
Stop
Start
.0047 µfd.
.0047 µfd.
100K
22K
47K
4.7K
2N3638
910 µµfd
10 µµfd
100 µfd
100K
ext.
68K
5K
15v.
2K
1.5K
68K
10K
1 meg.
15 µfd.
15K
2N3566
1K
0.1 µfd.
2N3565
330K
3.9K
220 µµfd.
.01 µfd.
10 Ω
220 Ω
momentary-contact push-button
Alternate pulses out
All pulses out
220 µµfd.

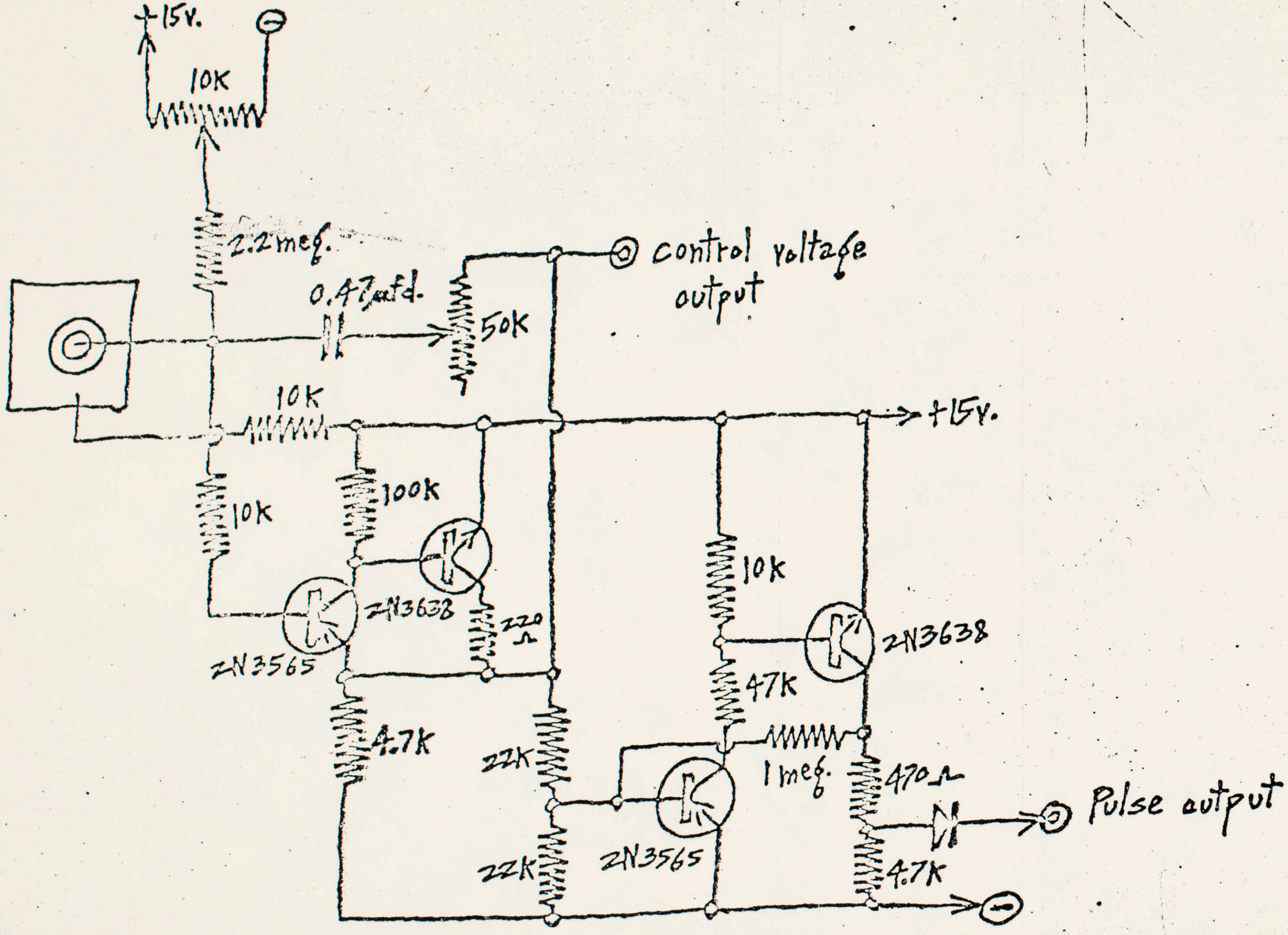
Buchla Timing Pulse Generator
(model 140)


to other stages
10K
2N3638
4.7K
+15v.
220Ω
470Ω
220Ω
Voltage output #1
2N3565
10K
to second row pot.
to third row pot.
stages 3-on only
3 4 5 6 7 8 9 10 11
etc.
-ditto-
voltage output #2
-ditto-
" " #3
+15v.
2N3638
470
100Ω
2N3638
470Ω
Pulse output
2N3566
Indicator Lamp
to other stages
1.5K
2N3566
22K
2.2K
910 μμfd
to other stages
2N3565
22K
150Ω
680Ω
to other stages (not used in stage 1)
to stage 1 only
2N3565
to other stages
+15v.
2N3638
10K
15K
2N3565
10K
910 μμfd.
680Ω
6.8K
2N3565
22K
47 μμfd.
timing pulse input
3.3K
1K
15K
3.57K
10K
100K

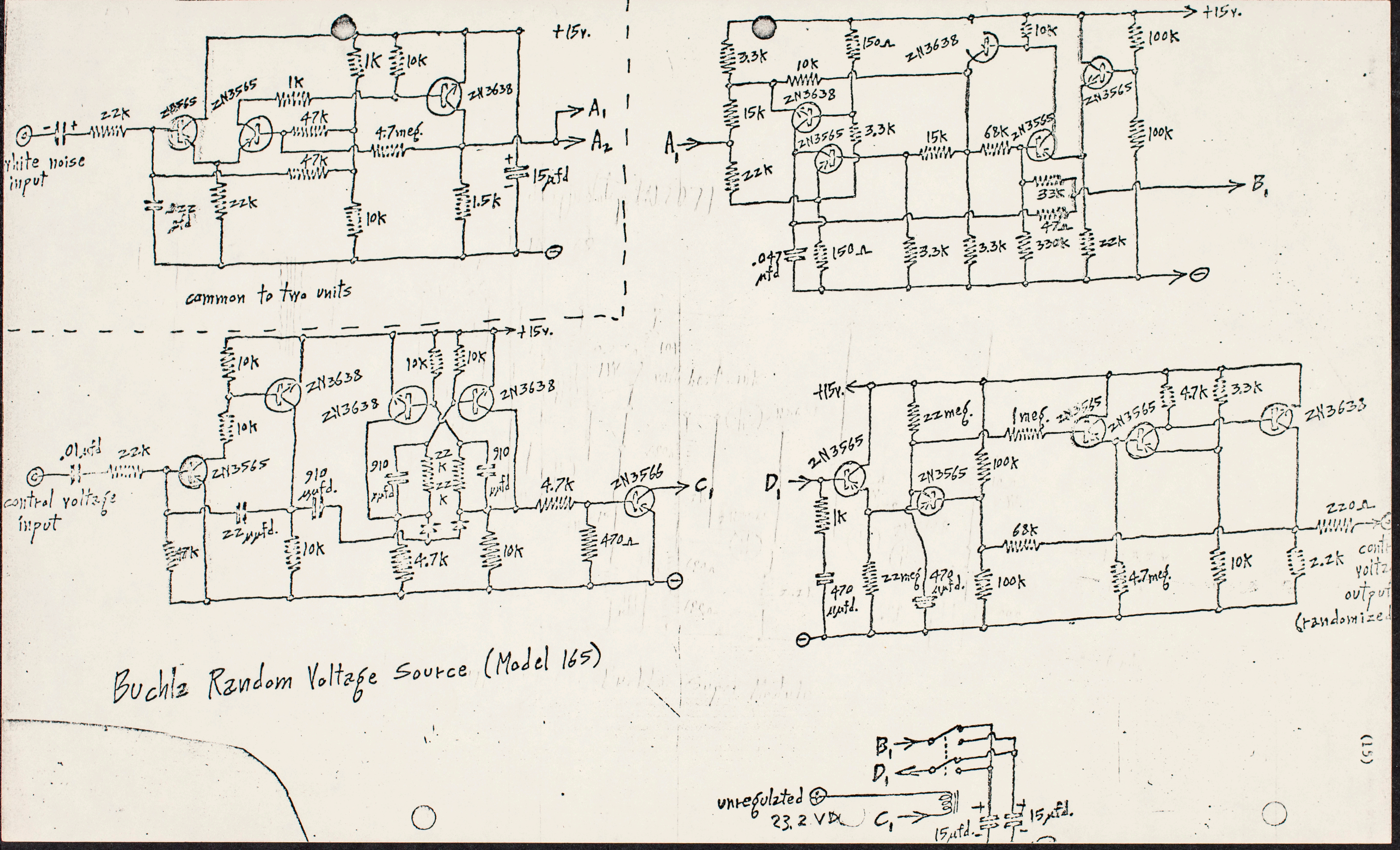
Buchla Sequential Voltage
Source
(model 123 - 8 stages)
(model 146 - 16 stages)


+15V.
2N3638
10k
68K
.047µfd.
10K
47K
2N3638
Output "C"
150Ω
(controlled by finger pressure)
2N3565
2N3565
22K
47K
2N3565
150Ω
trigger output
ignore
1 meg.
680Ω
10K
33K
2.2K
2.2K
47K
220Ω
to other units
10K
+15V.
22K
2N3565
2N3638
2N3638
10Ω
P.C. Board
etched area
10 meg.
2.2 meg.
10K
Voltage adjustments
+15V.
4.7K
220Ω
220Ω
Output "A" (controlled by finger pressure)
2N3638
2N3565
from other units
ignore
10K
10K
ditto
Output "B" (ditto)
from other units
12 units in all
common to all units

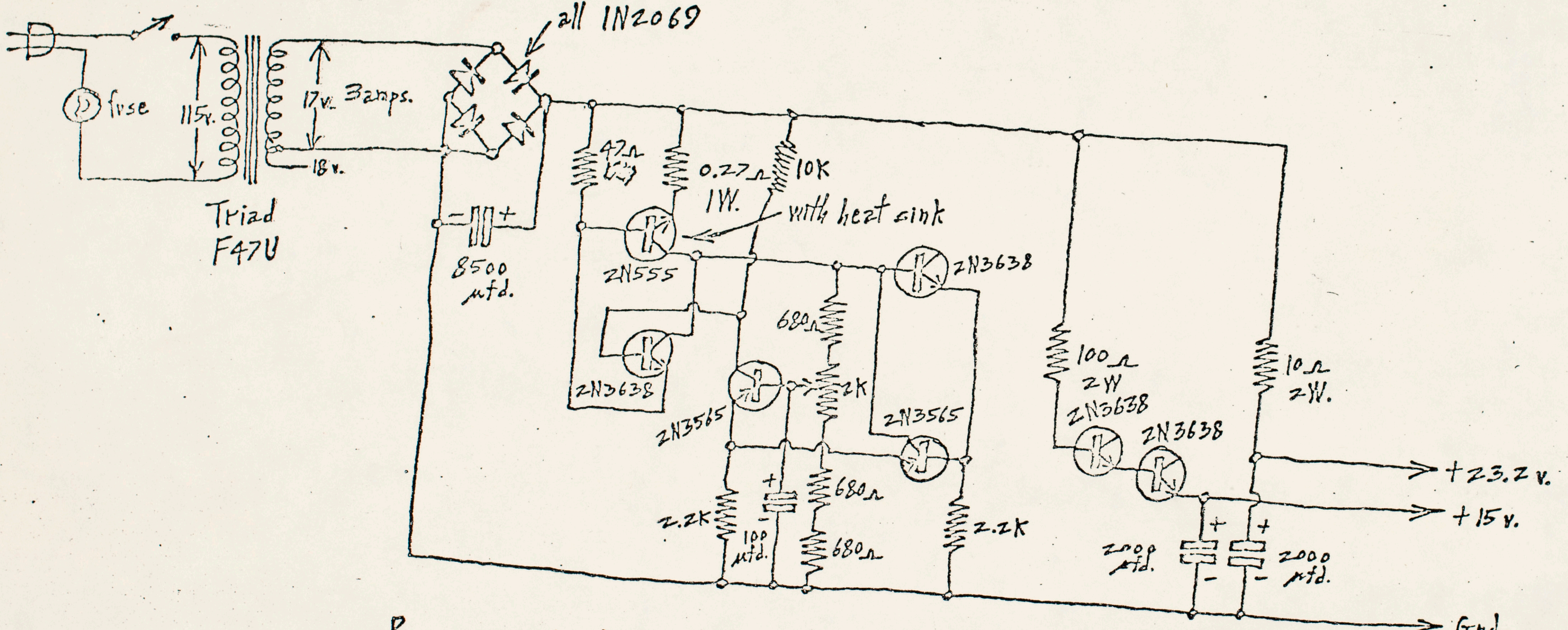
Buchla Touch-controlled Voltage Source (model 112)


+15v.
10K
2.2meg.
0.47mfd.
50K
control voltage output
10K
+15v.
10K
100K
2N3638
220Ω
2N3565
4.7K
22K
22K
10K
2N3638
47K
1meg.
470Ω
2N3565
Pulse output
4.7K

Buchla Touch-controlled Voltage Source (model 114)


white noise input
22k
2N3565
1K
10k
2N3638
47k
4.7meg.
+15v.
A1
A2
15µfd
1.5k
22k
10k
common to two units
3.3k
150Ω
15k
22k
2N3638
2N3565
3.3k
68k
100k
33k
47Ω
330k
.047 µfd
150Ω
B1
control voltage input
.01µfd
22µµfd.
910 µµfd.
910
22 K
4.7k
470Ω
2N3566
C1
D1
1k
470 µfd.
22meg.
1meg.
100k
3.3k
2N3638
220Ω
2.2k
4.7meg.
contr voltz output (randomized
unregulated
23.2 VDC
15µfd.

Buchla Random Voltage Source (Model 165)


all IN2069
fuse
115v.
17v. 3amps.
18v.
Triad
F47U
8500
µfd.
47Ω
0.27Ω
1W.
10K
with heat sink
2N555
2N3638
2N3638
680Ω
2K
2N3565
2N3565
2.2K
100
µfd.
680Ω
680Ω
2.2K
100Ω
2W
10Ω
2W.
2N3638
2N3638
+23.2 v.
+15 v.
2000
µfd.
2000
µfd.
Gnd.

Mills prototype IN2071

Power Supply for One Buchla Super Module

Model 158 Dual Sine-sawtooth Oscillator.

Two independent oscillators in one unit. Frequencies are continuously variable from 5 cps to 20 kc and may be controlled internally or with externally applied voltages. Wave shape may be adjusted from sine (1% harmonic content) to sawtooth (60% harmonic content). The oscillators may be wide-band frequency modulated over five octaves.

Model 144 Dual Square Wave Oscillator.

Two independent oscillators in one unit. Frequencies are continuously variable from 5 cps to 10 kc and may be controlled internally or with externally applied voltages. There is provision for up to 100% amplitude modulation and up to five octaves of wide-band frequency modulation.

Model 132 Waveform Synthesizer.

Used to generate complex, repetitive waveforms. The desired waveform is approximated by setting the instantaneous amplitude of each of 32 increments. Aural feedback, random knob-twiddling, and (desirably) an accessory oscilloscope contribute to achieving the desired sound. Frequency is continuously variable from 1 cps to 2 kc and may be controlled internally or with an externally applied voltage. The instrument may be frequency modulated and a synchronizing trigger is provided to facilitate oscilloscope monitoring.

Model 160 White Noise Generator.

Produces white noise with a flat frequency distribution from 5 cps to 20 kc and weighted noise with a constant power per octave distribution. When used as a frequency modulation source for oscillators, the resultant sound is similar to filtered white noise. The purity of this "pink noise" is inversely proportional to the amplitude of frequency modulation.

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SIGNAL PROCESSORS

Model 111 Dual Ring Modulator.

Two independent, linear, ring modulators in one unit. Ring modulators are a variety of balanced modulators in which the output consists of the sum and difference frequencies of two input signals. The original signals are suppressed about 30 db.

Model 190 Dual Reverberation Unit.

Two spring-type reverberators. Amount of reverberation is adjustable. Reverberation is used to add brilliance to original material, to achieve a stereophonic effect from a monophonic source, or to simulate the natural reverberation of a large room or cavern.

Model 170 Dual Microphone Preamplifier.

Two high-gain mike preamplifiers in one unit. Input connectors are 3-pin XLR. Input impedences are selected by a panel-mounted switch.

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Model 106 Mixer.

Two 3-channel mixers with both separate and common outputs and level controls for each input. Maximum gain is 5 db.

Model 107 Voltage-Controlled Mixer.

Two 5-channel mixers with separate and common outputs. Input levels are controlled by externally applied voltages normally derived from a Model 114 touch-controlled voltage source. Maximum gain is 5 db.

Model 110 Dual Voltage-Controlled Gate.

Dual fast-response gate. Gain is determined by control voltages such as those derived from a Model 180 attack generator. Maximum gain is 5 db.

Model 120 Distributor.

A cross mixer with four inputs and five outputs. Any input may be connected to any output by applying a voltage at the appropriate point in the control matrix.

The Model 120 may be used in conjunction with the Model 113 voltage source for directing the origin of sounds within a room.

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SAN FRANCISCO TAPE MUSIC CENTER
MODULAR ELECTRONIC MUSIC

CONTROL VOLTAGE AND TIMING PULSE SOURCES

Model 112 Touch-Controlled Voltage Source.

Two voltages are controlled by 12 keys. When a key is touched, the resultant output voltages are determined by the setting of potentiometers adjacent to that key. These voltages may be used to control oscillator frequencies, in which case 12 preselected notes can be instantly obtained by touching appropriate keys.

A third output voltage is proportional to finger pressure, and, when used to control a gate (Model 110), enables direct control of the signal amplitude.

A pulse output appears when a key is activated and is useful for triggering an attack voltage generator (Model 180) for shaping the attack and decay characteristics of a note.

Model 113 Touch-Controlled Voltage Source.

A touch-sensitive keyboard consisting of four circles, each of which is divided into five segments (1 central and 4 peripheral). Touching a segment causes an increase in voltage at a corresponding output. Switch-selected time constants provide extended attack and decay times. 20 potentiometers control the output voltages independently of or in conjunction with the keyboard.

Used with the Model 120 distributor, the Model 113 enables a performer to manipulate the origin of sounds within a room. Used with Model 310 lamp drivers, spatial control of room lighting may be realized.

Model 114 Touch-Controlled Voltage Source.

A 10 key touch-controlled keyboard with a control voltage output and a pulse output corresponding to each key. The voltage outputs are normally used to control gates (110) or mixers (107), and the pulse outputs for initiating attack waveforms (180) or other events. The time constant associated with each key is independently and continuously variable.

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Model 123 Sequential Voltage Source.

Produces a sequence of two to eight preselected voltages at each of three outputs. Switching from one voltage to the next is accomplished by applying a pulse. Indicator lamps show which of the 24 potentiometers are in control. Eight pulse outputs are energized as corresponding segments are switched.

Used in conjunction with a timing pulse generator (140), the Model 123 can produce two programmed sequences of voltages with any desired timing. (The third output voltage controls the period.)

Model 146 Sequential Voltage Source.

Produces a sequence of 2 to 16 preselected voltages at each of three outputs. Otherwise identical to Model 123.

Model 180 Dual Attack Generator.

Two independent units on one panel produce envelope control voltages initiated by pulses. Attack time is variable from .005 to 1 second; decay time from .05 to 5 seconds; and duration from .05 to 5 seconds. Duration may optionally be controlled by trigger pulse length.

Normally used with Model 110 gate for note shaping.

Model 140 Timing Pulse Generator.

A source of timing pulses for establishing a rhythmic element. The period may be varied from .1 to 10 seconds, and the pulse length from 1% to 99% of the period. Both parameters may be controlled internally or by externally applied voltages.

The Model 140 may be used to trigger the Model 180 attack generator, Model 123 voltage sequencer, and/or the Model 165 random voltage source.

Model 165 Random Voltage Source.

Produces two uncorrelated, random output voltages, each of which is changed by applying a trigger pulse. Used to randomize frequencies, amplitudes and timing.

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The following systems are presented as examples of complete, well-balanced Modular Electronic Music Systems:

Modular Electronic Music System No. 1

A single super-module consisting of the following components:

1 Model 100 Cabinet
2 Model 106 Mixers
1 Model 110B Dual Voltage-Controlled Gate
1 Model 111A Dual Ring Modulator
1 Model 112 Touch-Controlled Voltage Source
1 Model 115 Power Supply
1 Model 123 Sequential Voltage Source
1 Model 140 Timing Pulse Generator
1 Model 156 Dual Control Voltage Processor
3 Model 158 Dual Sine-sawtooth Oscillators
1 Model 160 White Noise Generator
1 Model 180 Dual Attack Generator
1 Model 144 Square Wave Oscillator
1 Model 190 Dual Reverberation Unit
1 Patch Cord Set

Modular Electronic Music System No. 2

Two super-modules consisting of the following components:

2 Model 100 Cabinets
3 Model 106 Mixers
1 Model 107 Voltage-Controlled Mixer
2 Model 110B Dual Voltage-Controlled Gates
1 Model 111A Dual Ring Modulator
2 Model 112 Touch-Controlled Voltage Sources
1 Model 114 Touch-Controlled Voltage Sources
2 Model 115 Power Supplies
1 Model 123 Sequential Voltage Source
1 Model 124 Patch Board
2 Model 140 Timing Pulse Generators
1 Model 144 Square Wave Oscillator
1 Model 146 Sequential Voltage Source
2 Model 156 Dual Control Voltage Processors
4 Model 158 Dual Sine-sawtooth Oscillators
1 Model 160 White Noise Generator
1 Model 165 Random Voltage Source
1 Model 170 Dual Microphone Preamplifier
2 Model 180 Dual Attack Generators
1 Model 190 Dual Reverberation Unit
2 Patch Cord Sets

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MISCELLANEOUS AND AUXILIARY EQUIPMENT

Model 100 Cabinet.

Specially designed mahagony cabinet accommodates power supply and 15 panel units. (Most modules are 4¼" x 7" and occupy one panel unit, but some are 8½" or 17" wide and take up 2 or 4 panel units.) Over-all dimensions are 23" x 23" x 8".

Model 115 Power Supply.

Regulated supply for powering a cabinet full of modules plus one or two keyboards. Normally installed in Model 100 cabinet, unit occupies no panel space.

Model 124 Patch Board.

Consists of 24 miniature phone jacks mounted on a panel and connected to a rear-mounted terminal strip. Used in studio installations to terminate lines from external sources or to tape recorders and other auxiliary equipment.

Model 156 Dual Control Voltage Processor.

Serves to mix, compress, and invert control voltages. Each channel has one normal input, one inverting input, and one internal voltage source. Particularly useful for obtaining fine pitch control and for compressing the range of the Model 165 random voltage source.

Patch Cord Set.

Consists of sufficient patch cords to program one super-module and one or two keyboards.

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SAN FRANCISCO TAPE MUSIC CENTER
MODULAR ELECTRONIC MUSIC

PRICE INFORMATION

Model No.	Panel Units	Description	Price
100	0	Cabinet	$ 70.
106	1	Mixer	55.
107	2	Voltage-Controlled Mixer	160.
110B	1	Dual Voltage-Controlled Gate	75.
111A	1	Dual Ring Modulator	95.
112	0	Touch-Controlled Voltage Source	130.
113	0	Touch-Controlled Voltage Source	210.
114	0	Touch-Controlled Voltage Source	140.
115	0	Power Supply	60.
120	2	Voltage-Controlled Distributor	235.
123	2	Sequential Voltage Source	180.
124	1	Patch Board	35.
132	2	Waveform Synthesizer	190.
140	1	Timing Pulse Generator	70.
144	1	Dual Square Wave Generator	110.
146	4	Sequential Voltage Source	290.
156	1	Dual Control Voltage Processor	95.
158	1	Dual Sine-sawtooth Generator	130.
160	1	White Noise Generator	75.
165	1	Random Voltage Source	140.
170	1	Dual Microphone Preamplifier	125.
180	1	Dual Attack Generator	80.
190	1	Dual Reverberation Unit	135.
		Patch Cord Set	45.
		Complete System No. 1	1720.
		Complete System No. 2	3420.

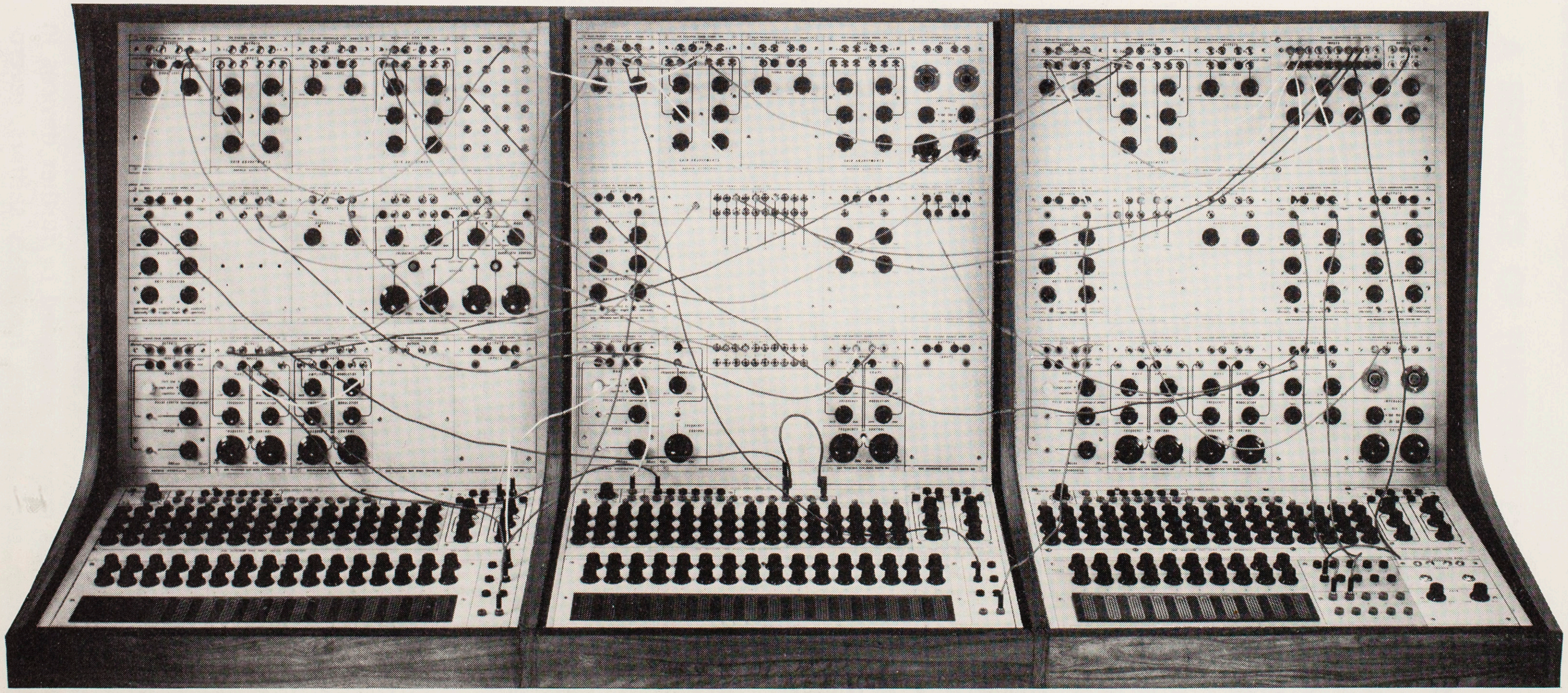
The numbers in the "panel units" column indicate the relative space occupied in the cabinet by the corresponding modules. Total the number of panel units desired in a system and order one power supply (115) and cabinet (100) for each 15 (or portion thereof) panel units.

660408

Buchla

Buchla Electronic Music System
Users Manual written for CBS
Musical Instruments by
Dr. Hubert Howe, Queens
College, New York.

Buchla Electronic Music System



Pauline Oliveros
Music Dept.
University of California
At San Diego

USER'S GUIDE TO THE BUCHLA MODULAR ELECTRONIC MUSIC SYSTEM

INTRODUCTION

1. Modules

The first thing you will probably notice about your equipment is that each unit assembled in the cabinet is of the same basic size, 7 inches high and 4¼ inches wide or a multiple thereof. These individual units are called **modules,** and they are each designed to perform various specific functions, which are described in detail below. On most modules, there are a number of **jacks** at the top of the unit and various **dials** and switches below. Usually the top row of jacks is for **outputs** and the row underneath for **inputs,** although there are some modules that have no inputs, and some modules have the jacks located at the right end. Most outputs are available at **multiple** jacks, in order that they may be connected to more than one input. When there are dials which determine some aspect of an input at a particular jack, there is a line drawn from the dial to the jack in question. The functions of all jacks, dials and switches are clearly labelled on each module. At the very top of the module is printed its name and model number.

Many **dual** modules are included in the Buchla System. A dual module is actually two independent modules within one panel. Sometimes they are totally independent (such as the Model 165 Dual Random Voltage Source) and sometimes they are capable of being either independent or interconnected (such as the Model 106 Six-Channel Mixer).

2. Signals

After you have examined the individual modules in your cabinet, the next thing that you will probably notice is that there are different kinds of jacks and patch cords for the system. A **patch cord** is a wire with a plug connected at each end, which is used to carry signals from one module to another. Patch cords are of several colors, which are used to distinguish different lengths. The system employs three basic varieties of signals, each with a distinctly different function:

(1) **Audio Signals** are simply **sounds.** They may be **generated** internally by various modules such as oscillators or harmonic generators, or they may come from external sources such as a tape recorder or microphone. Audio signals may be **processed** by further devices in the system, such as filters, frequency shifters, reverberation units, etc. until they are finally taken in some form and passed to a tape recorder or speaker. The final sound which is played or recorded is called the **system output.** (The synthesizer can produce several system outputs at one time.) The patch cords carrying audio signals within the system terminate with grey **miniature phone plugs** at each end. A standard level of 0 db (ref. 600 ohms) is employed for audio signals. (Sometimes audio signals will be referred to simply as "signals".)

(2) **Control Voltages** are signals which are used to determine the **operating characteristics** of various modules in the system. For example, the frequency of an oscillator may be determined either by a dial on the front panel or by a control voltage coming from another module. Control voltages may determine practically any aspect of a sound, and the use and significance of this principle is explained in detail below. Control voltages are processed at **Black** jacks on the front panels of the modules, and they are carried by patch cords terminating in black **banana plugs.** Timing pulses, as explained below, also use patch cords ending in banana plugs, but you have been provided with two sets of these patch cords, one with red plugs and one with black plugs. To avoid confusion, it is suggested that you use the **black** patch cords for control voltages, though the color of the plugs, of course, makes no difference. Control voltages range from .5 to 15 volts.

(3) **Timing Pulses** are signals which **initiate** or **trigger** events on other modules. The events initiated may be a single note or entire series of events. Timing Pulses are produced by touch controlled voltage sources, sequencers, or timing pulse generators. They are processed at **red** jacks on the modules, and they are carried by patch cords terminating in red **banana plugs.** Timing pulses are approximately 10 volts in amplitude.

There are two rules which must be followed in connecting signals from one module to another: (1) The path of flow must always be from the **outputs** of one module to the **inputs** of other modules, and (2) the jacks at each end of the connection must be the same. That is, audio signals must be connected to audio signals, control voltages to control voltages, and timing pulses to timing pulses.

3. The Concept of Voltage Control

Voltage Control is the principle which allows the operating characteristics of various modules to be determined by other modules. In such a way, the settings on various instruments can be dynamically varied without the composer having to intervene manually, and the compositional magnitude of the system is greatly increased. Voltage control is one of the most important characteristics of the system, which makes the equipment much more powerful and flexible than any of the devices in older "classical" electronic music studios.

In the Buchla System, there are several modules whose purpose is solely to generate and process control voltages. There are other modules which generate or process audio signals only, and there are further modules which combine control voltages and audio signals in such a way that some characteristic of the audio signal is determined by the control voltage.

Modules which generate or process control voltages or timing pulses only are referred to as **compositional** (or semi-compositional) modules, for they can be used to determine various aspects of a piece of music such as the pitch, amplitude, or duration of a sequence of notes. These characteristics can be entirely predetermined, by setting various dials before running through the composition, or entirely random, or these two extremes can be combined to any desired degree. Under certain circumstances, the equipment can actually be made to "compose" music all by itself, in a manner that will be described in detail below (see Example 2).

On the other hand, modules which generate or process audio signals only are referred to as **performance** modules, for the actual sounds they produce must be determined either by the composer (who chose the settings on the dials) or by control voltages determined by compositional modules. A major part of learning how to use the system involves learning how to use the principle of voltage control in such a way that the composer's hands are not tied up in too many operations at one time.

On modules that have external-internal switches to allow some characteristics of a signal to be determined either by a dial on the front panel or by an external control voltage, there is generally an approximate relationship between the dial on the panel and the dials on the external devices such as that when both dials are pointing in the same direction, they should produce the same result. This relationship is only approximate, however, and must always be checked by ear. In general, the accuracy with which modules can be controlled is only to within certain broad limitations. The dials are usually marked only within the upper and lower limits of their capabilities, and intermittent values must be determined by approximation. Any predetermined series of pitches or other frequency characteristics must be tuned by ear.

It is important to remember that all control voltages within the system are completely compatible, so that any module which has a control voltage output can be used to control any other module with a control voltage input. Therefore, the same control voltage can determine more than one property of a sequence of notes, so that, for example, the rhythm of a passage can correspond precisely to a succession of pitches or amplitudes, or the envelope generator can be used to produce a change in frequency as well as amplitude. The use of control voltages in ways that might not be suggested by the most ordinary interconections is encouraged, and further demonstrates the versatility and imagination of the system.

A SEQUENCE OF TUTORIAL EXAMPLES

Example 1

Let us start with the simplest possible example, that of a single tone. Take the system output* from any output jack on the Model 158 Dual Sine-Sawtooth Oscillator, and make sure that the external-internal switch is set to "internal". By manipulating the bottom dial, you can vary the frequency of the tone from 5 to 20,000 cycles per second, and by moving the top dial you can change the timbre of the tone from a pure sine wave, TO A SAWTOOTH → which contains all harmonic partials (theoretically) in a descending amplitude series. The middle dial, marked "frequency modulation", has a line connected to an audio signal input jack, and has no effect on the tone unless another audio signal is patched into it. This signal may be taken either from another oscillator or from the other side of the dual oscillator in this panel. When connected, the frequency of frequency modulation is determined by the frequency of the input signal and the amplitude of frequency modulation by the middle dial.

Suppose now that you want to determine the frequency of the oscillator by some other means, in order to run through a series of notes, for example. Make a connection from either of the top two rows of jacks in the Model 112 Touch Controlled Voltage Source to the control voltage input on the oscillator, and set the external-internal switch to "external". Now the frequency of the oscillator is determined by one of the dials on the Model 112 Touch Controlled Voltage Source—the dial which is directly above the last key to be touched and to the left of the row of jacks from which the connection to the oscillator is made. Moving your finger from one key to the next causes the dial which determines the frequency to be changed, except that when you remove your finger entirely the last value simply holds. The different positions on the dial which is used to control frequency from the Touch Controlled Voltage Source have aproximately the same value as the internal frequency dial on the oscillator itself, so that when both are pointing in the same direction they should produce the same frequency. (This important relationship between internal and external control voltage dials is maintained on all modules with external-internal switches similar to that on the Model 158 Dual Sine-Sawtooth Oscillator.) Now a succession of frequencies may be tuned individually on the dials on the Model 112 Touch Controlled Voltage Source, and played through in any rhythm. (The Model 112 Touch Controlled Voltage Source can also produce a control voltage proportional to finger pressure on any key, but this provides such a wide range of voltages that it is usually necessary to use it in conjunction with a Model 156 Dual Control Voltage Processor.)

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*The manner in which the system output may be taken depends upon the provisions made at your particular installation. In some cases the Model 124 Patchboard may be directly wired as a central patch panel in a studio, where all tape recorders, microphones, and other devices may be interconnected. In other cases a special patch may be made from the system output jack to a tape recorder input or power ampilfier and speaker. In all examples described here, it will be assumed that the system output can be immediately accessible to the user, so that anyone going through these steps exactly will be able to stop and hear the result at any intermediate stage.

At this point, however, we notice that all of the attacks of the notes are instantaneous, and they never cut off unless the system output is unplugged; the tones have no envelope. To correct this problem, it is necessary to use a Model 180 Dual Attack Generator and Model 110 Dual Voltage-Controlled Gate (or a Model 107 Voltage-Controlled Mixer). The Model 180 Dual Attack Generator produces a control voltage which has an attack, duration, and decay of determinable times. In order to apply this control voltage to the amplitude of a tone, it is necessary to use the Model 110 Dual Voltage-Controlled Gate.

The Model 180 Dual Attack Generator produces its envelope when it receives a timing pulse input from another module. In order to have it produce an envelope at the same time that a key on the Model 112 Touch Controlled Voltage Source is touched, it is necessary to patch from the timing pulse output on the Model 112 Touch Controlled Voltage Source is touched, it is necessary to patch from the timing pulse output on the Model 112 keyboard to the timing pulse input on the Model 180 Attack Generator, to connect the control voltage output on the Model 180 Attack Generator to the control voltage input of the Model 110 Dual Voltage-Controlled Gate, and to patch the audio signal output from the Model 158 Oscillator to the audio signal input on the Model 110 Gate. The system output is then available at the audio signal output of the Model 110 Gate (see Figure 1A).

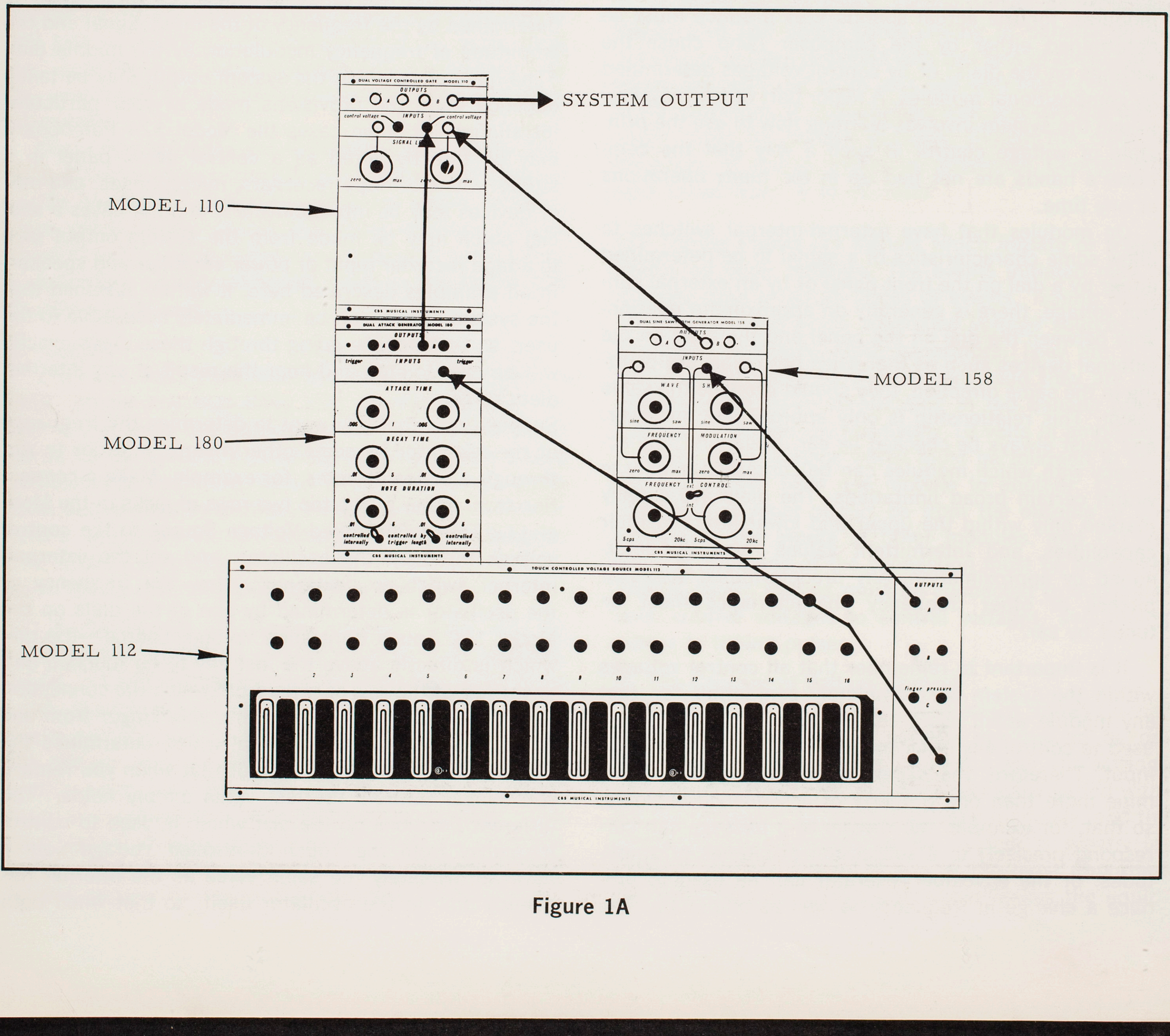

SYSTEM OUTPUT
MODEL 110
MODEL 158
MODEL 180
MODEL 112
DUAL VOLTAGE CONTROLLED GATE MODEL 110
OUTPUTS
INPUTS
control voltage
control voltage
zero
max
zero
max
CBS MUSICAL INSTRUMENTS
DUAL ATTACK GENERATOR MODEL 180
OUTPUTS
trigger
INPUTS
trigger
ATTACK TIME
DECAY TIME
NOTE DURATION
controlled internally
controlled by trigger length
controlled internally
CBS MUSICAL INSTRUMENTS
OUTPUTS
INPUTS
WAVE
sine
saw
sine
saw
FREQUENCY
MODULATION
zero
max
zero
max
FREQUENCY
ext
CONTROL
int
5cps
20kc
5cps
20kc
CBS MUSICAL INSTRUMENTS
TOUCH CONTROLLED VOLTAGE SOURCE MODEL 112
OUTPUTS
finger pressure
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
CBS MUSICAL INSTRUMENTS

Figure 1A

The attack and decay characteristics of the tones may now be controlled by the dials on the Model 180 Dual Attack Generator. The top dial controls the attack time, which may be varied from .002 to 1 seconds; the decay time is controlled by the middle dial, and may be varied from .002 to 5 seconds. By moving the external-internal switch to the "external" position, it is possible to make the note duration be determined by the trigger length, which in this case is the length of time you leave your finger on the keyboard. The dial on the Model 110 Dual Voltage-Controlled Gate allows a further seting of the final amplitude level of the tone.

Now it is posible to run through an entire series of tones of predetermined frequencies in a rhythm which will be determined by the way you touch the keys on the Model 112 Touch Controlled Voltage Source.

At this point we may consider various additional signal modifications that we may wish to make to the series of tones produced by the above example. For instance, if we would like to add frequency modulation to the tones, it is necessary to patch another audio signal into the jack connected by a line to the middle dial on the Model 158 Dual Sine-Sawtooth Oscillator. The amplitude of frequency modulation is controlled by the middle dial, and turning the amplitude all the way down can eliminate the frequency modulation entirely. The frequency and "shape" of frequency modulation are determined by the characteristics of the input signal, which for this reason is called the "modulating" tone. To judge this effect precisely, compare the frequency-modulated tone to the modulating tone as separate audio signals by taking the system output from each side of the Model 158 Dual Sine-Sawtooth Oscillator.

If we wish to take both the modulating tone and the basic tone from both sides of the Model 158 Dual Sine-Sawtooth Oscillator, we must use an additional control voltage to determine the frequency of the modulating tone, for the external-internal switch controls both oscillators in this case. (We are assuming that the other side of the oscillator is still connected as in Figure 1A.) This control voltage could be taken from the other row of dials on the Model 112 Touch Controlled Voltage Souce, in which case we could preset the frequencies of both oscillators and go through an entire series of frequency-modulated tones (see Figure 1B).

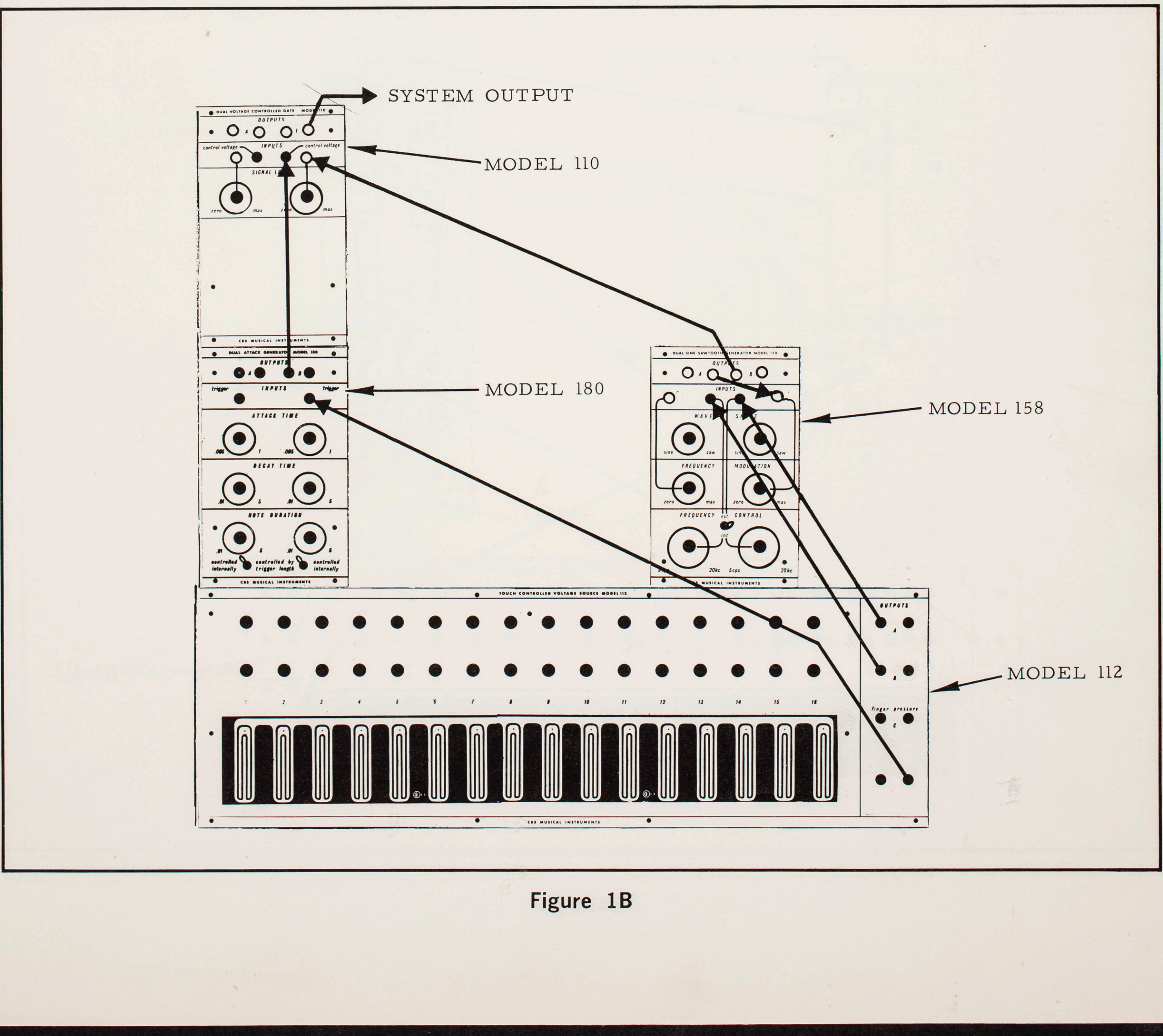

SYSTEM OUTPUT
MODEL 110
MODEL 180
MODEL 158
MODEL 112
DUAL VOLTAGE CONTROLLED GATE
OUTPUTS
INPUTS
control voltage
SIGNAL LEVEL
zero
max
CBS MUSICAL INSTRUMENTS
DUAL ATTACK GENERATOR MODEL 180
trigger
ATTACK TIME
DECAY TIME
NOTE DURATION
controlled internally
controlled by trigger length
DUAL SINE SAWTOOTH GENERATOR MODEL 158
WAVE
SHAPE
sine
saw
FREQUENCY
MODULATION
FREQUENCY CONTROL
ext
int
20kc
5cps
TOUCH CONTROLLED VOLTAGE SOURCE MODEL 112
finger pressure
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16

Figure 1B

Instead of using one tone to frequency-modulate another in this manner, we may chose simply to mix the two tones together into one sound. This could be accomplished by using the Model 106 Six-Channel Mixer. We need to patch simply from the two outputs on the Model 158 Dual Sine-Sawtooth Oscillator to any of the inputs on the Model 106 Mixer, and from one of the center outputs on the Model 106 Mixer (marked "all") to the audio signal input on the Model 110 Gate. The amplitude of each of the tones is now controlled separately by the dials leading to each of the input jacks on the Model 106 Mixer. The Model 106 Mixer has six inputs, so that up to six separate tones can be combined at one time. The left and right sides of the mixer can also be used separately as two three-channel mixers, and the corresponding output jacks are on the outside of the top row of jacks (marked "1-3" and "4-6"). Although in this example the amplitudes of each of the tones is controlled separately by the dials on the front panel of the Model 106 Mixer, it is important to remember that the pair of tones will have the same envelope and total amplitude, for they are being combined into one signal (see Figure 1C).

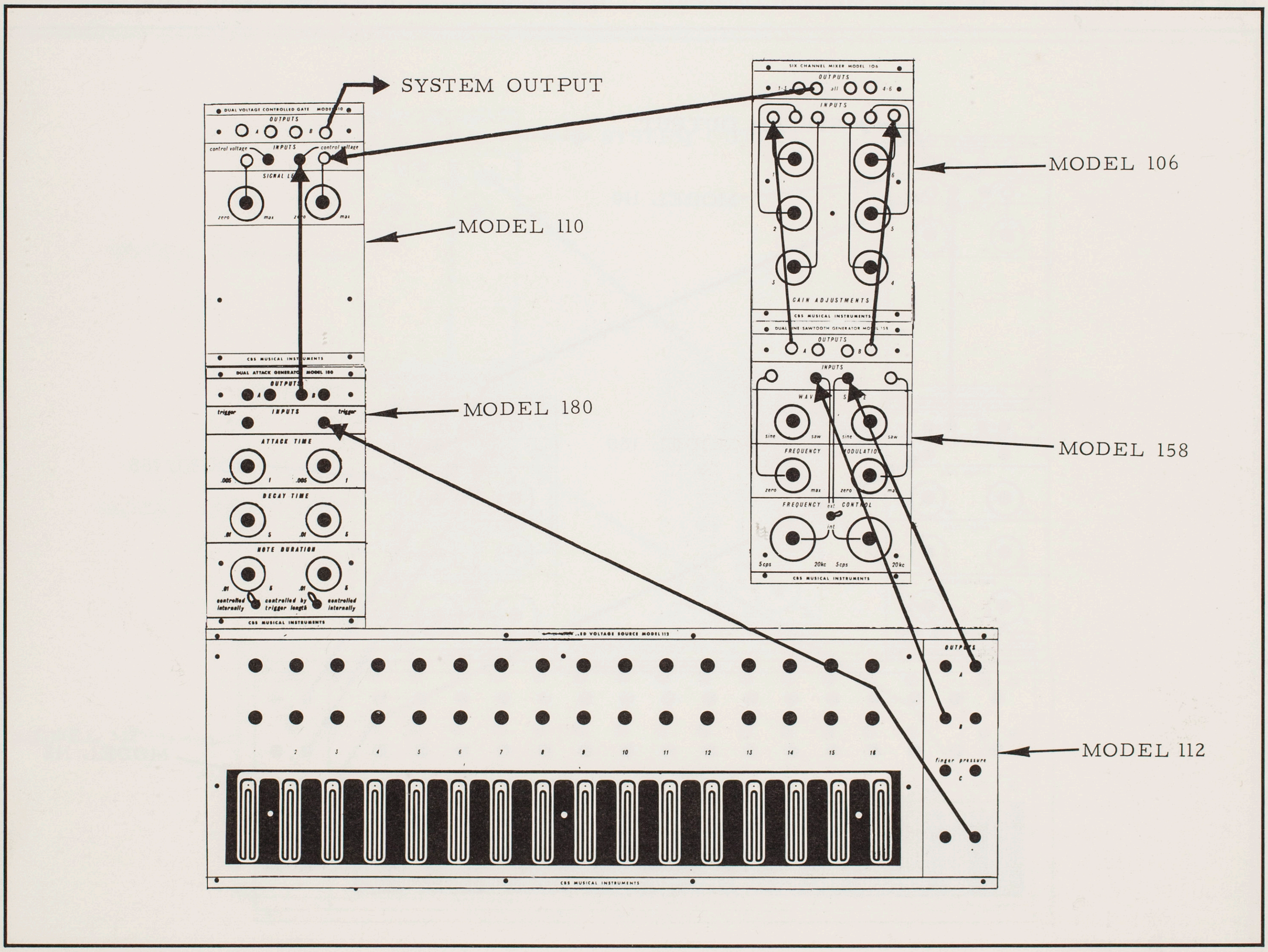

SYSTEM OUTPUT
MODEL 110
MODEL 180
MODEL 106
MODEL 158
MODEL 112
DUAL VOLTAGE CONTROLLED GATE MODEL 110
OUTPUTS
INPUTS
control voltage
SIGNAL LEVEL
zero
max
CBS MUSICAL INSTRUMENTS
DUAL ATTACK GENERATOR MODEL 180
trigger
ATTACK TIME
DECAY TIME
NOTE DURATION
controlled internally
controlled by trigger length
SIX CHANNEL MIXER MODEL 106
1-3
all
4-6
GAIN ADJUSTMENTS
DUAL SINE SAWTOOTH GENERATOR MODEL 158
WAVE SHAPE
sine
saw
FREQUENCY MODULATION
FREQUENCY CONTROL
ext
int
5cps
20kc
finger pressure
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16

Figure 1C

Now suppose we would like to set up a series of tones of different predetermined and correlated amplitudes and frequencies. In this case it would be convenient to use one row of dials on the Model 112 Touch Controlled Voltage Source to control frequency and the other to control amplitude, and so we must find a module which applies a control voltage to amplitude. Such a module would be either the Model 107 Voltage-Controlled Mixer or the Model 110 Dual Voltage Controlled Gate. Since we are already using one side of the Model 110 Gate for envelope control, it would be convenient to use the other side to control amplitude. It is necessary to patch from the desired control voltage output on the Model 112 keyboard to the control voltage input on the unused side of the Model 110 gate, and from the audio signal output of the envelope side of the Model 110 gate (which was the system output in Figure 1A) to the audio signal input on the opposite side, and the system output is now available at the output of this side of the Model 110 gate. The settings on the dials of the Model 112 keyboard bear the same relationship to the amplitudes of the tones as the corresponding settings of the dial on the front panel of the Model 110 gate, so that this dial can be used as a "master volume control" for the entire series of tones produced by this patching set-up (see Figure 1D).

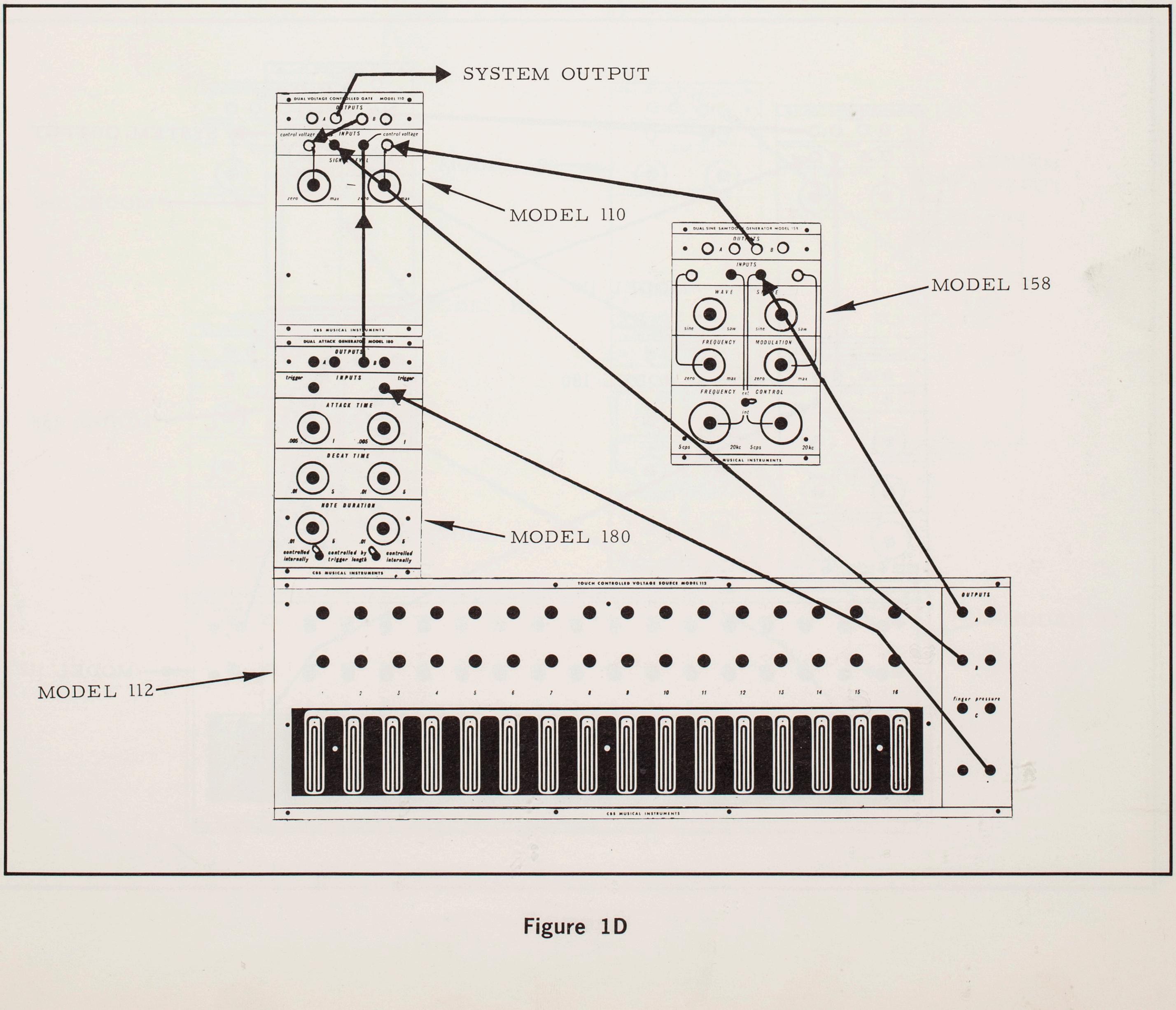


Figure 1D

Now we are in a position to consider how any general signal modification could be added to a tone which has already been generated and processed to some degree: we need to patch simply from the signal output (which up to know has been taken as the system output) to the signal input on a new device, and then take the system output from the new device. This process can be repeated until any desired degree of signal modification is achieved. For example, suppose we would like to add reverberation to a signal output from Example 1A. We need to patch only from the audio signal output of the Model 110 gate in Example 1A to the signal input on either side of a Model 190 Dual Reverberation Unit, and take the system output from one of the two output jacks immediately above the input we selected (see Figure 1E). The dial in this case controls the amount of reverberation in the final sound.

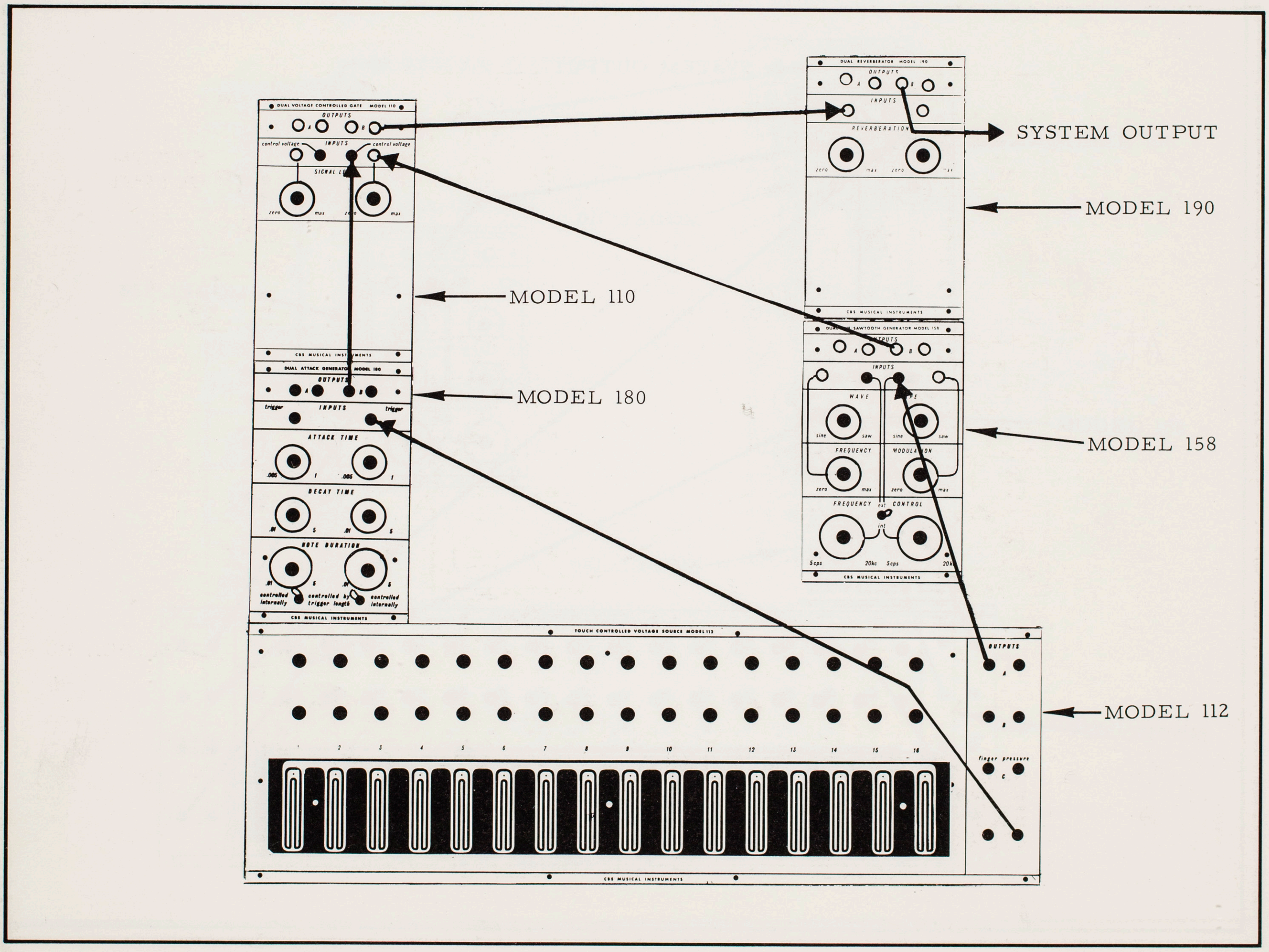

DUAL VOLTAGE CONTROLLED GATE MODEL 110
OUTPUTS
INPUTS
control voltage
SIGNAL LEVEL
zero
max
CBS MUSICAL INSTRUMENTS
DUAL ATTACK GENERATOR MODEL 180
trigger
ATTACK TIME
DECAY TIME
NOTE DURATION
controlled internally
controlled by trigger length
DUAL REVERBERATOR MODEL 190
REVERBERATION
SYSTEM OUTPUT
MODEL 190
MODEL 110
MODEL 180
WAVE
sine
saw
FREQUENCY
MODULATION
FREQUENCY CONTROL
ext
int
5cps
20kc
MODEL 158
TOUCH CONTROLLED VOLTAGE SOURCE MODEL 112
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
finger pressure
MODEL 112

Figure 1E

Now suppose we wish to add a low filter to the sound just produced in Example 1E. All we need to do is patch the output of the reverberation unit in Example 1E to the input on either side of a Model 192 Dual Lo-pass Filter, and take the system output from the filter (see Figure 1F). The dial on the Model 192 Filter now controls the on/off frequency of the lowpass filter. Note that it makes no difference whether we patch the reverberation unit or the filter in first, as long as the final sound passes through all of these modules before being taken as the system output. This is a general rule which holds for any signal processing; extensive modifications can be compounded one onto another, and as long as the system output is taken after all of the modifications, the results will be the same, regardless of the order in which they are applied.

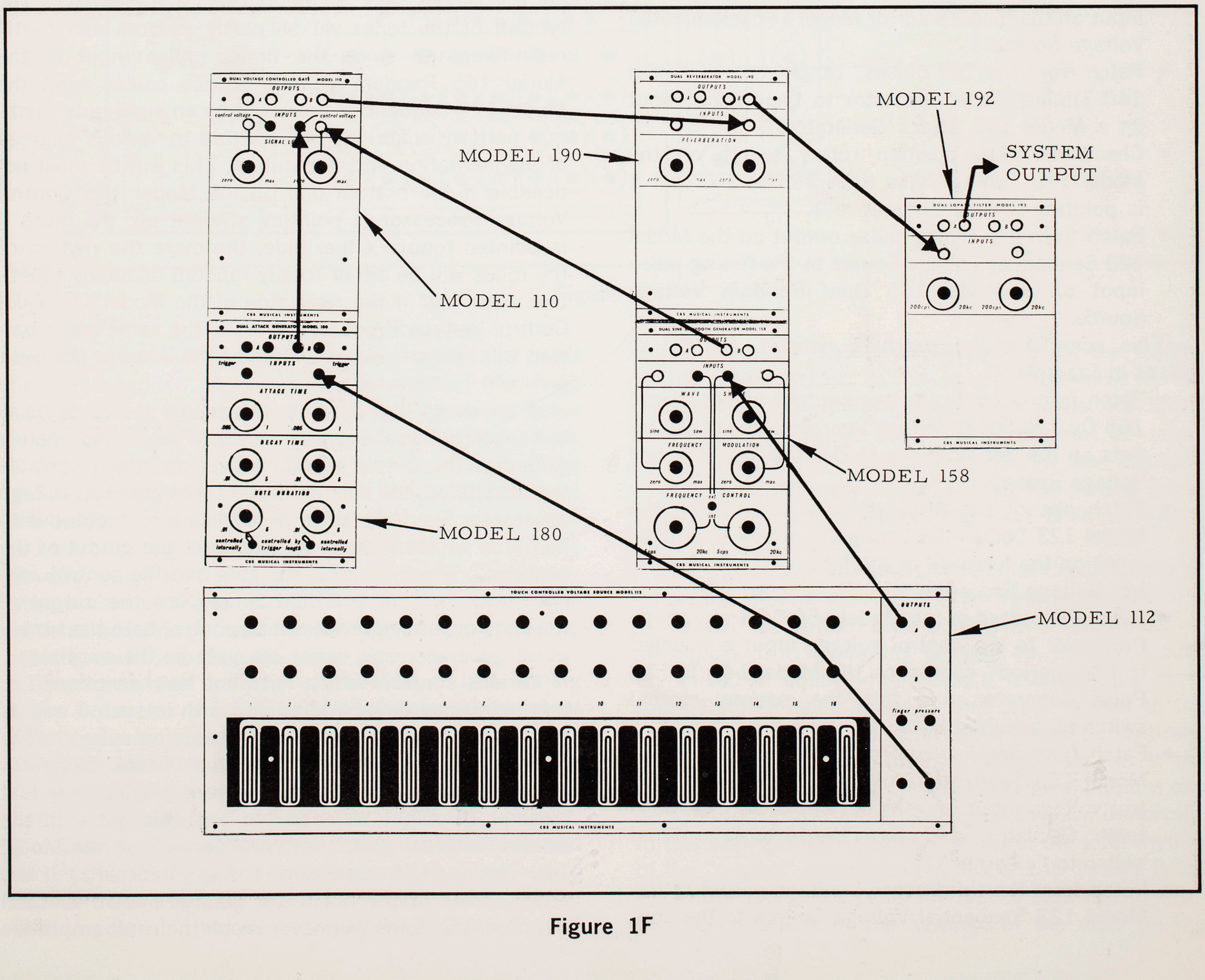

DUAL VOLTAGE CONTROLLED GATE MODEL 110
OUTPUTS
INPUTS
control voltage
SIGNAL LEVEL
zero
max
DUAL REVERBERATOR MODEL 190
REVERBERATION
MODEL 192
SYSTEM OUTPUT
MODEL 190
DUAL LOPASS FILTER MODEL 192
200cps
20kc
MODEL 110
CBS MUSICAL INSTRUMENTS
DUAL ATTACK GENERATOR MODEL 180
trigger
ATTACK TIME
DECAY TIME
NOTE DURATION
controlled internally
controlled by trigger length
DUAL SINE-SAWTOOTH GENERATOR MODEL 158
WAVE
SHAPE
sine
saw
FREQUENCY
MODULATION
FREQUENCY CONTROL
ext
int
5cps
20kc
MODEL 158
MODEL 180
TOUCH CONTROLLED VOLTAGE SOURCE MODEL 112
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
finger pressure
MODEL 112

Figure 1F

Example 2

Now we are ready to consider a more complicated example. Suppose we would like to generate a sequence of partly predetermined, partly random tones differentiated by pitch, rhythm, and amplitude. It is actually very easy to solve problems of this kind with the Buchla System, because of the versatility of compositional devices and the complete compatibility of control voltages.

It is clear that we will have to use the Model 165 Dual Random Voltage Source in this example, but we will also need a module which can combine the random voltage with a predetermined voltage. Such a module would be the Model 156 Dual Control Voltage Processor. We will also use the Model 140 Timing Pulse Generator and the Model 123 Sequential Voltage Source as compositional modules in this example.

First, if you have moved to this example after finishing Example 1, it would be helpful to remove all the patches from the modules and start from scratch. Then follow these directions:

- Patch from the "all pulses" output on the Model 140 Timing Pulse Generator to the timing pulse input on the Model 123 (or Model 146) Sequential Voltage Source.
- Patch from the "all pulses" output on the Model 140 Timing Pulse Generator to the trigger input on a Model 180 Attack Generator.
- Check the three-position rotary switch on the Model 140 Timing Pulse Generator to see that it is pointing toward "repetitive".
- Patch from any timing pulse output on the Model 123 Sequential Voltage Source to the timing pulse input on a Model 165 Dual Random Voltage Source.

(This completes the patching network for timing pulses in Example 2)

- Patch from a control voltage output on the Model 165 Dual Random Voltage Source to one of the inputs on the left side of a Model 156 Dual Control Voltage Processor.
- Patch one of the three pairs of outputs on the Model 123 Sequential Voltage Source to the other input on the left side of the Model 156 Dual Control Voltage Processor.
- Patch the output of the Model 156 Control Voltage Processor to the control voltage input connected to the "period" control on the Model 140 Timing Pulse Generator, and turn the external-internal switch to "external".
- Patch from another control voltage output of the Model 123 Sequential Voltage Source to the control voltage input on a Model 158 Dual Sine-Sawtooth Oscilator, and turn the external-internal switch to "external".
- Patch from the third control voltage output of the Model 123 Sequential Voltage Source to the control voltage input on the left side of a Model 110 Dual Voltage Controlled Gate.
- Patch from the output of the Model 180 Attack Generator to the control voltage input on the right side of the Model 110 Dual Voltage Controlled Gate.

(This completes the patching network for control voltages in Example 2)

- Patch the audio signal output of the Model 158 Dual Sine-Sawtooth Oscillator to the audio signal input on the right side of the Model 110 Dual Voltage Controlled Gate.
- Patch the output of the right side of the Model 110 Dual Voltage Controlled Gate to the audio signal input on the left side of the same Model 110 Dual Voltage Controlled Gate.
- The system output is now available as the output of the left side of the Model 110 Dual Voltage Controlled Gate. This entire network of patches is illustrated in Figure 2.

In this set-up, the pitch and amplitude of the tones will be repetitive and controlled by the associated dials on the Model 123 Sequential Voltage Source. The ryhthm of the tones wil be partly random and partly repetitive, and since the timing pulse input to the Model 165 Random Voltage Source comes from the Model 123 Sequencer, there will be an eight-note rhythmic pattern which will be repeated in various degrees of augmentation and diminution. This will be most noticeable if the bottom dial on the Model 156 Control Voltage Processor is pointing straight up; the more it is pointed toward either side, the more the rhythm of the tones will be either totally random or totally repetitive. Note that if the right side of the Model 156 Dual Control Voltage Processor is used, the same basic pattern will emerge, but the value of the input in the right jack will be inverted.

If we would like the pitches and not the rhythms in this example to be partly random, we could merely exchange the output of the sequencer which controls the oscillator and the output of the control voltage processor. Similarly, if we would like the amplitudes to be partly random, we could exchange the output of the sequencer which controls the gate and the control voltage processor; or we could simply use the output of the control voltage processor to control both the timing pulse generator and either the gate or the oscillator.

Various controls which have not been mentioned to this point may now be tampered with in such a way as to change the total effect of this patching network. The attack time on the Model 180 Dual Attack Generator should be fairly fast if the notes are moving in a fast rhythm. (It might be easier to test this out with the external-internal switch for the "period" on the Model 140 Timing Pulse Generator set to "internal".) If the attack times of the notes are greater than their total duration, the notes will never reach their full amplitude

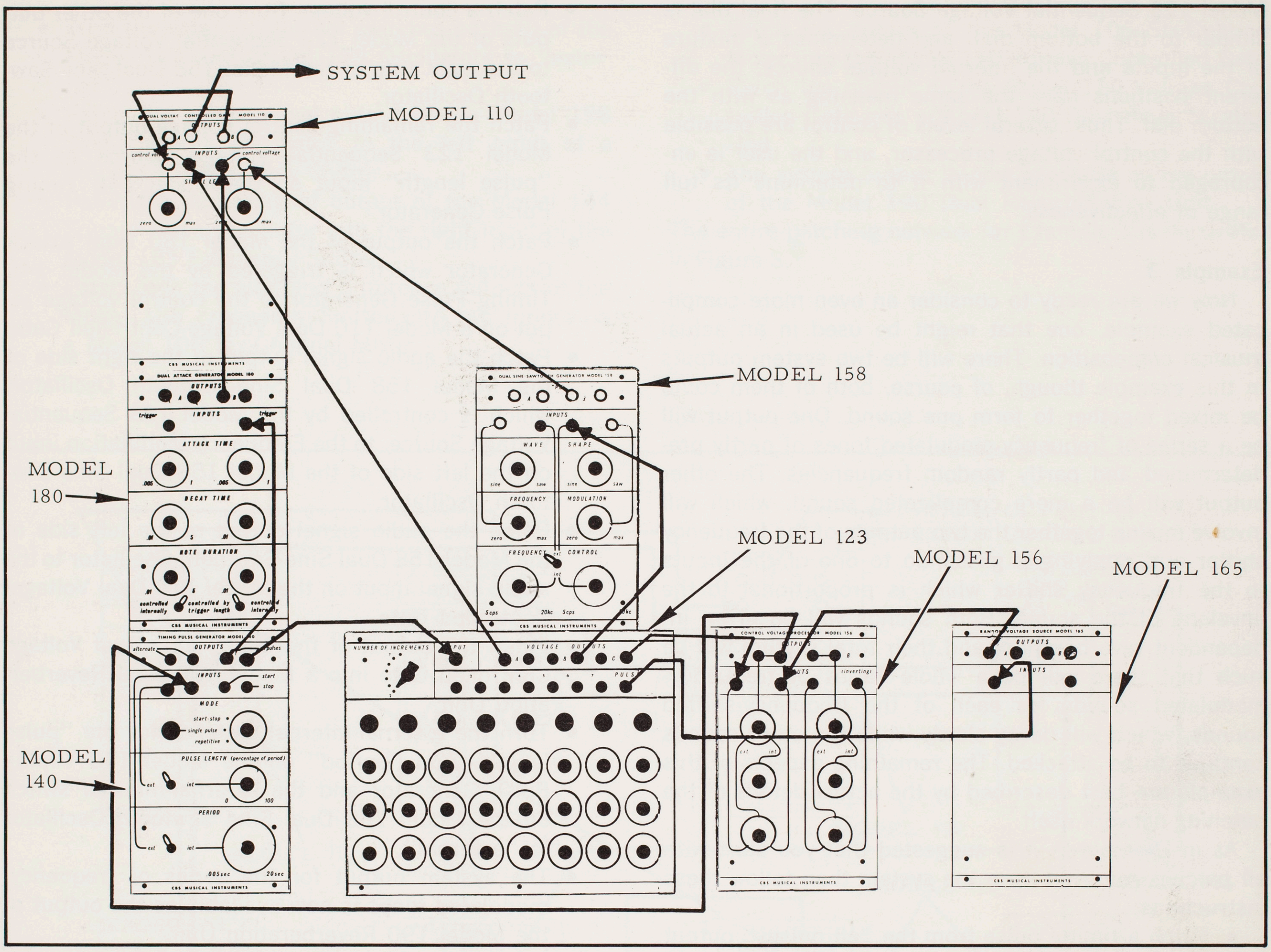

SYSTEM OUTPUT
MODEL 110
MODEL 158
MODEL 180
MODEL 123
MODEL 156
MODEL 165
MODEL 140
OUTPUTS
INPUTS
ATTACK TIME
DECAY TIME
NOTE DURATION
MODE
PULSE LENGTH (percentage of period)
PERIOD
WAVE
SHAPE
FREQUENCY
MODULATION
FREQUENCY CONTROL
CBS MUSICAL INSTRUMENTS

Figure 2

and the result will be either silence or a series of "muffled crescendos." Similarly, the duration of the tones can be either constant or determined by the pulse length, which in this case is controlled by the middle dial on the Model 140 Timing Pulse Generator. If the duration of the tones is constant, it should be less than the amount of time between successive attacks, which is controlled by the "period" control (either internally or externally) on the Model 140 Timing Pulse Generator; otherwise the tones will have no decay times. Any of these possible permutations still give comprehensible results, and could be used compositionally.

There are two controls on the Model 140 Timing Pulse Generator which have external-internal switches: The "pulse length" and the "period". For purposes of demonstration, let us use the "internal position" for the time being, though for compositional purposes both could be determined by external control voltages. The period control determines the duration between successive timing pulse outputs, and the pulse length control determines the duration of each timing pulse. With the duration switch on the Model 180 Attack Generator set such that it is determined by the trigger length, these controls can be used to determine the total rhythmic structure of a sequence of tones, which can be dynamically varied since the values can be determined by external control voltages. In the example shown, it is interesting to note that the timing pulse generator controls the sequencer and is in turn controlled by the sequencer.

The controls on the Model 156 Dual Control Voltage Processor allow a great variety of means to determine the result. The bottom dial determines a mixture of the two inputs: if it is pointing straight up, the two inputs are mixed in equal amplitudes; if it is pointing more toward either input, more of that input is sent to the output, until finally the other input is cut out entirely. The middle dial is an internal voltage source. If the control voltage processor is used to control pitch, it can be used to transpose the pitches up or down uniformly. In this example it can be used to make the total rhythm of the "period" control on the Model 140 Timing Pulse Generator produce a generally fast or slow result, within the limitations of the settings of the dials on the
]

Model 123 Sequential Voltage Source. The final dial is similar to the bottom dial, and determines a mixture of the inputs and the internal voltage source: the different positions have the same meaning as with the bottom dial. Thus, several levels of control are possible with the control voltage processor, and the user is encouraged to experiment with it to determine its full range of effectiveness.

Example 3

Now we are ready to consider an even more complicated example, one that might be used in an actual musical composition. There will be two system outputs in this example though, of course, both of them could be mixed together to form one sound. One output will be a series of frequency-modulated tones of partly predetermined and partly random frequencies. The other output will be a more complicated sound, which will involve mixing together the two outputs of the frequency shifter and applying a glissando to one of the inputs to the frequency shifter which is proportional to the envelope of the sound. Both sounds will be given independent reverberation, and their total rhythm will be such that there will be a whole series of frequency-modulated sounds for each of the frequency-shifted sounds, which will decay slowly while the other sounds continue to be attacked. The remaining aspects of this example are best described by the actual details of the patching network itself.

As in Example 2, it is suggested that you start with all patches removed from the system then follow these instructions:

- Patch a timing pulse from the "all pulses" output of a Model 140 Timing Pulse Generator to the input on a Model 123 (or Model 146) Sequential Voltage Source.
- Patch from the "all pulses" output of a Model 140 Timing Pulse Generator to the trigger input on a Model 180 Attack Generator.
- Patch from two adjacent timing pulse outputs of the Model 123 Sequential Voltage Source to the timing pulse inputs on a Model 180 Attack Generator and on a Model 165 Random Voltage Source, in that order.
- Patch a control voltage from one of the three outputs of the Model 123 Sequential Voltage Source to one of the inputs on the left side of a Model 156 Control Voltage Processor.
- Patch the control voltage output from the Model 165 Random Voltage Source into the remaining input on the left side of the Model 156 Control Voltage Processor.
- Patch the output of the left side of the Model 156 Control Voltage Processor to both the "period" input on the Model 140 Timing Pulse Generator and to the left side of a Model 158 Dual Sine-Sawtooth Oscillator.
- Patch a control voltage from one of the other outputs of the Model 123 Sequential Voltage Source to the right side of the Model 158 Dual Sine-Sawtooth Oscillator.
- Patch the remaining control voltage output of the Model 123 Sequential Voltage Source to the "pulse length" input on the Model 140 Timing Pulse Generator.
- Patch the output of the Model 180 Dual Attack Generator which is triggered by the Model 140 Timing Pulse Generator to the control voltage input on a Model 110 Dual Voltage-Controlled Gate.
- Patch the audio signal output of the right side of the Model 158 Dual Sine-Sawtooth Oscillator, which is controlled by the Model 123 Sequential Voltage Source, to the Frequency Modulation input on the left side of the Model 158 Dual Sine-Sawtooth Oscillator.
- Patch the audio signal output of the left side of the Model 158 Dual Sine-Sawtooth Oscillator to the audio signal input on the Model 110 Dual Voltage-Controlled Gate.
- Patch the output of the Model 110 Dual Voltage Controlled Gate into a Model 190 Dual Reverberation Unit.
- Turn the external-internal switches for the "pulse length" and "period" on the Model 140 Timing Pulse Generator and the external-internal switch on the Model 158 Dual Sine Sawtooth Oscillator to "external".
- The system output for the series of frequency-modulated tones is now available as the output of the Model 190 Reverberation Unit.

The basic frequencies of the frequency-modulated tones are partly random, and are directly correlated to their rhythm. The modulation frequencies are repetitive. The entire character of the music can be changed by simply moving the dial on the Model 123 Sequential Voltage Source on the Model 156 Control Voltage Processor.

To set up the other half of this example, follow these directions:

- Patch control voltages from the Model 180 Dual Attack Generator which is triggered by the Model 123 Sequential Voltage Source to both a Model 110 Dual Voltage-Controlled Gate and to the left input on the right side of the Model 156 Dual Control Voltage Processor. Since this will be the only input to the right side of the Model 156, the bottom dial can be turned all the way in this direction.
- Patch the output of the right side of the Model 156 Dual Control Voltage Processor to the control voltage input on a Model 158 Dual Sine-Sawtooth Oscillator.
- Patch a control voltage from the Model 165 Random Voltage Source to the control voltage input on a Model 144 Dual Square Wave Oscillator.

- Turn the external-internal switches on both of the Model 144 and Model 158 Oscillators to "external".
- Patch the audio signal output of the Model 158 Sine-Sawtooth Oscillator to the left input of a Model 185 Frequency Shifter.
- Patch the audio signal output of the Model 144 Square Wave Oscillator into the right input of the Model 185 Frequency Shifter.
- Patch both the sum and difference outputs of the Model 185 Frequency Shifter into two inputs on a Model 106 Six-Channel Mixer.
- Patch the output of the Model 106 Six-Channel Mixer into the Model 110 Voltage Controlled Gate.
- Patch the output of the Model 110 Voltage Controlled Gate into a Model 190 Dual Reverberation Unit.
- The system output is now available as the output of the Model 190 Dual Reverberation Unit.

The entire patching network for Example 3 is illustrated in Figure 3.

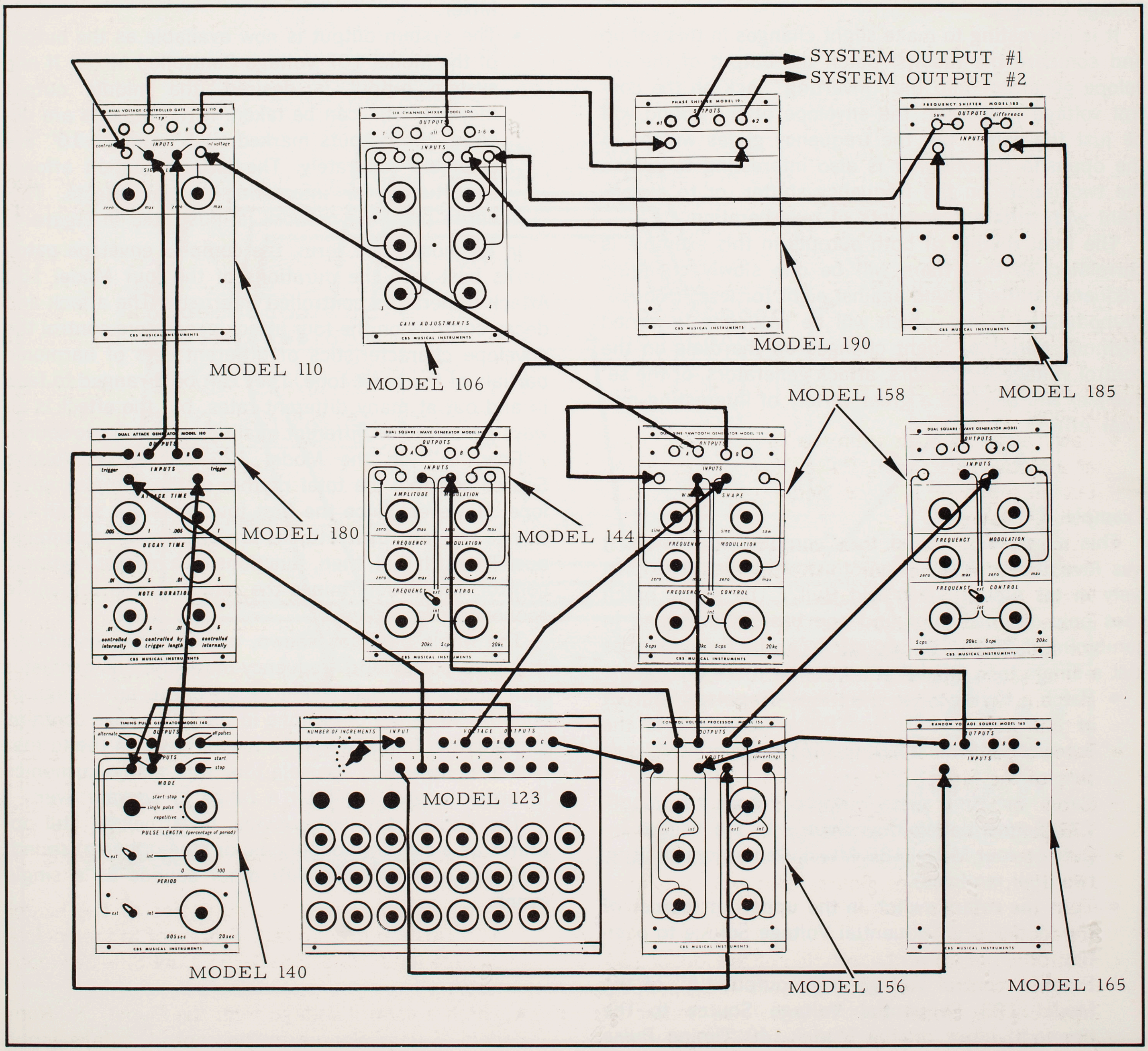

SYSTEM OUTPUT #1
SYSTEM OUTPUT #2
MODEL 110
MODEL 106
MODEL 190
MODEL 185
MODEL 158
MODEL 180
MODEL 144
MODEL 123
MODEL 140
MODEL 156
MODEL 165
DUAL VOLTAGE CONTROLLED GATE MODEL 110
SIX CHANNEL MIXER MODEL 106
GAIN ADJUSTMENTS
PHASE SHIFTER MODEL 190
FREQUENCY SHIFTER MODEL 185
sum
OUTPUTS
difference
INPUTS
DUAL ATTACK GENERATOR MODEL 180
ATTACK TIME
DECAY TIME
NOTE DURATION
DUAL SQUARE WAVE GENERATOR MODEL 144
DUAL SINE-SAWTOOTH GENERATOR MODEL 158
AMPLITUDE
MODULATION
FREQUENCY
FREQUENCY CONTROL
SHAPE
TIMING PULSE GENERATOR MODEL 140
MODE
PULSE LENGTH (percentage of period)
PERIOD
NUMBER OF INCREMENTS
INPUT
VOLTAGE OUTPUTS
CONTROL VOLTAGE PROCESSOR MODEL 156
RANDOM VOLTAGE SOURCE MODEL 165
CBS MUSICAL INSTRUMENTS

Figure 3

In order to realize the full effectivenes of this set-up, the decay time of the Model 180 Attack Generator should be quite long and the duration fairly short. In that way the frequency glide controlling the Model 185 Frequency Shifter will be quite long, and the manner in which the sound dies out will be more noticeable. It would also be possible to use the same timing pulse output of the Model 123 Sequencer to control both the attack generator and the Model 165 Dual Random Voltage Source, but this is not necessary if the timing pulse for the attack generator is taken immediately after that for the random voltage source; in that way the same value of the random voltage source can be maintained for nearly the whole duration of the sound, which will be at the end of its decay when the random voltage changes.

It is interesting to make slight changes in this set-up and compare the results: patch the output of the envelope generator into the "inverting" jack on the control voltage processor; the envelope of the sound will be just the same, but the frequency glides will be in the opposite direction. It is also interesting to switch the two inputs on the frequency shifter, or to experiment with different amounts of reverberation.

The total rhythm of both outputs in this example is correlated so that there will be one slowly changing frequency-shifted sound against eight (or less) frequency-modulated tones, which will be recurring in varied rhythmic patterns. Slight changes on the dials on the control voltage processors, attack generators, or the sequencer will produce a great variety of interesting musical effects.

Example 4

This example is called the "complex envelope". It was invented by Morton Subotnick who used it extensively in his album "The Wild Bull". The entire patch uses only one oscillator and one basic sound, and in combining it with other sounds it can be thought of as just a single tone. To set it up, follow these directions:

- Patch a timing pulse from the "all pulses" output of a Model 140 Timing Pulse Generator to the input on a Model 123 (or 146) Sequential Voltage Source.
- Patch the time pulse outputs 1-4 on the Model 123 Sequential Voltage Source to the trigger inputs on four Model 180 Attack Generators (that is, **two** dual modules).
- Turn the rotary switch in the upper left corner of the Model 123 Sequential Voltage Source to position 5.
- Patch a control voltage from output "A" of the Model 123 Sequential Voltage Source to the "period" input on the Model 140 Timing Pulse Generator, and turn the external-internal switch to "external".
- Turn the first four control voltage dials for row "A" of the Model 123 Sequential Voltage Source all the way to the left, and set the fifth approximately in the middle.
- Patch the control voltage outputs of the four Model 180 Attack Generator to control voltage inputs number 1, 2, 6, and 7 on a Model 107 Voltage Controlled Mixer.
- Patch the audio signal output of a Model 158 Dual Sine-Sawtooth Oscillator to the input on a Model 195 Format Filter, and turn the wave shape control to "sawtooth".
- Patch any four outputs of the Model 195 Octave Format Filter into the audio signal inputs number 1, 2, 6 and 7 on the Model 107 Voltage Controlled Mixer.
- The system output is now available as the output of the Model 107 Voltage Controlled Mixer. If one system output is desired, the middle output marked "all" can be taken. If two outputs are desired, the outputs marked "1-5" and "6-10" are available separately. The latter situation affords opportunity for interesting spatial effects. This entire patching network is illustrated in Figure 4.

In its most basic form, the complex envelope patch works best with the durations of the four Model 180 Attack Generators controlled internally. The attack and decay controls on the four attack generators control the envelope characteristics of different sets of harmonic partials of the basic tone. They can be arranged to fade in and out at many different rates, but the effect is always perceived as different qualities of one basic sound.

Row "A" on the Model 123 Sequential Voltage Source controls the total rhythm of the complex envelope. However, since the first four dials are set all the way to the left, their attacks are effectively instantaneous. The fifth dial, then, functions as a master rhythmic control, which determines the rate at which the entire sequence progresses.

The whole patch as shown, uses just one oscillator, It is also possible to frequency-modulate one oscillator with another, which produces an entire new range of sounds. Since the basic tone in the latter case contains combination tones, it can be a sine wave. In the former case it is necessary to use a tone with many harmonics in order to give the filter a range to operate over.

The Entire complex envelope, nevertheless, still operates as a single (monophonic or stereophonic) sound, and can be combined with other sounds as a single event.

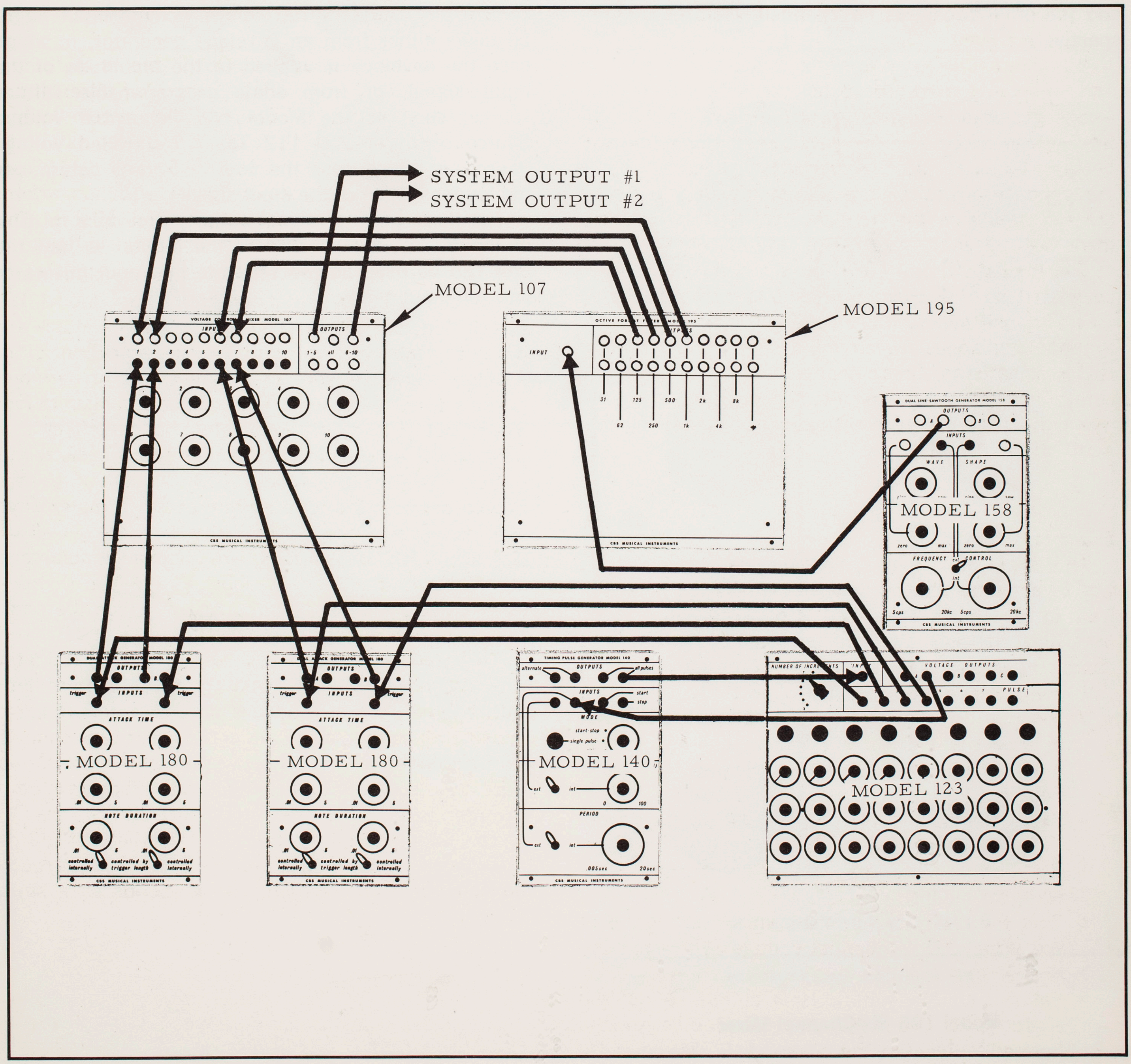

SYSTEM OUTPUT #1
SYSTEM OUTPUT #2
MODEL 107
MODEL 195
MODEL 158
MODEL 180
MODEL 180
MODEL 140
MODEL 123
OUTPUTS
INPUTS
1-5
all
6-10
INPUT
31
62
125
250
500
1k
2k
4k
8k
WAVE
SHAPE
zero
max
FREQUENCY
CONTROL
int
5cps
20kc
trigger
ATTACK TIME
NOTE DURATION
controlled internally
controlled by trigger length
TIMING PULSE GENERATOR MODEL 140
alternate
all pulses
start
stop
MODE
start-stop
single pulse
ext
int
PERIOD
.005sec
20sec
NUMBER OF INCREMENTS
VOLTAGE OUTPUTS
PULSE
CBS MUSICAL INSTRUMENTS

Figure 4

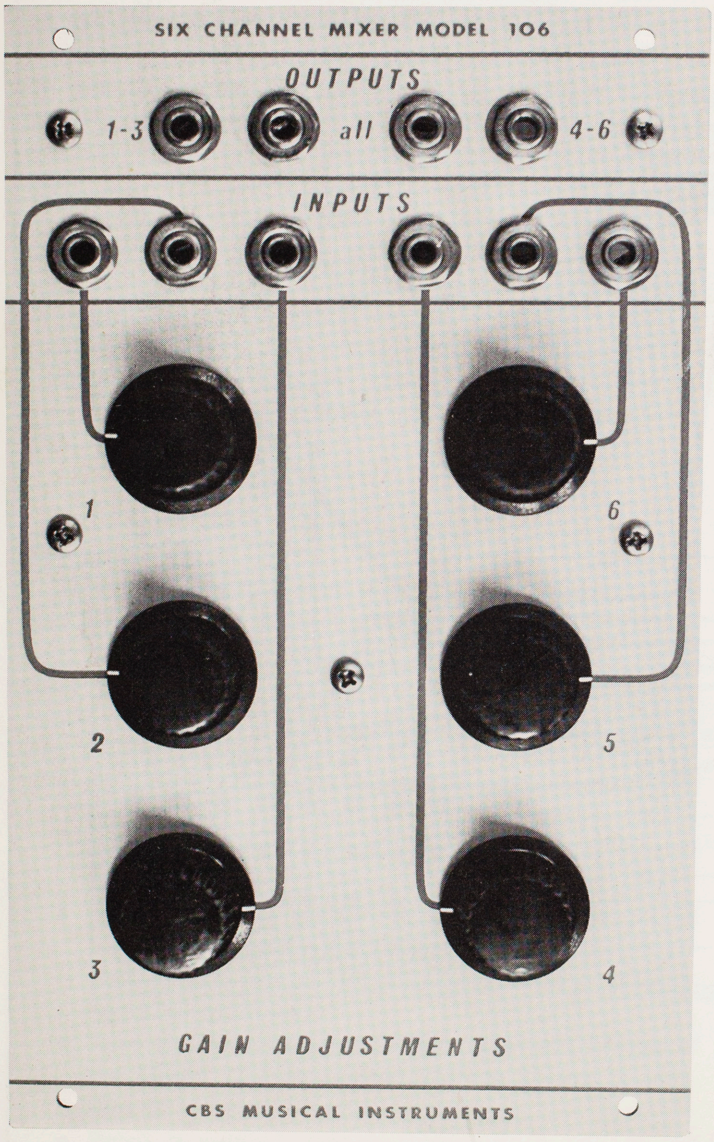
DESCRIPTION OF INDIVIDUAL MODULES

Model 106 Six-Channel Mixer

The Model 106 Six Channel Mixer contains six **signal inputs** and four **signal outputs** and six **volume controls** for the inputs on its front panel.

Lines are drawn on the panel between the **input jacks** and the associated **volume controls.** The volume level of each of the inputs may be separately set by these controls, but there is no master gain control for the output.

The Model 106 Six-Channel Mixer is really three-channel mixers with separate and common outputs. The middle two outputs are for the sum of the six inputs, and the other two jacks for channels 1-3 and 4-6, respectively.



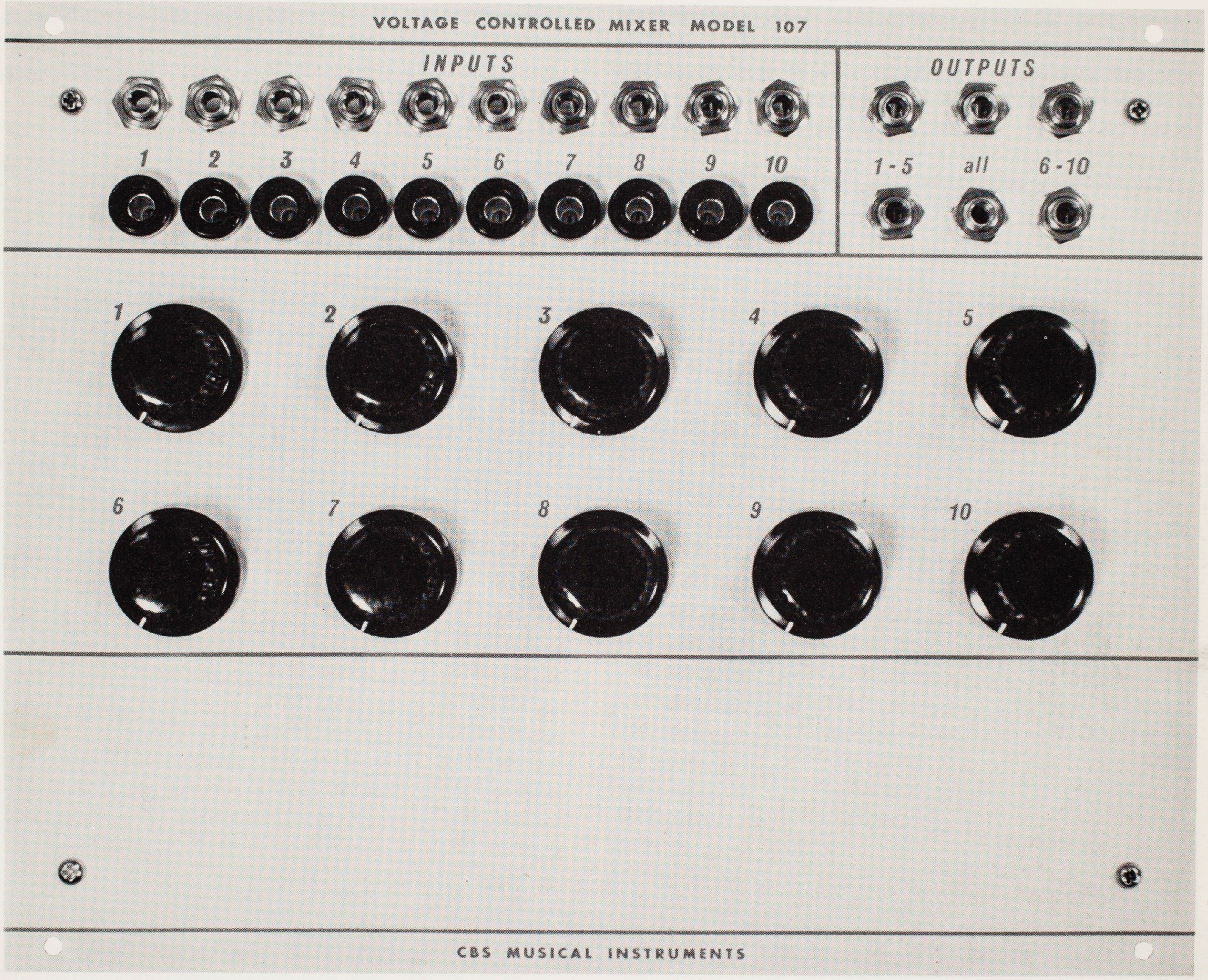
Model 106 Six-Channel Mixer

Model 107 Voltage-Controlled Mixer

The Model 107 Voltage-Controlled Mixer provides a way of applying a control voltage to the amplitudes of ten audio signals and mixing the result into one or two separate complex signals. Its front panel has ten associated **signal inputs, control voltage inputs,** and **volume control dials,** and three pairs of vertically aligned **signal outputs.**

The associated **signal** and **control voltage inputs** are vertically aligned and are numbered 1-10. The **volume control dials** are also numbered to indicate their correspondence to the inputs. The final amplitudes of the audio signal inputs are a result of the control voltage input and the setting on the dial, so that two levels of control are provided. The control voltage input might be taken either from an envelope generator, in which case the envelope is applied to the amplitude of the input signal, or from some programmable voltage source, such as the Model 146 Sequential Voltage Source or the Model 112 Touch Controlled Voltage Source, in which case the control voltage determines the loudness level of the input signal.

The three pairs of **signal outputs** provide a mixture of inputs 1-5, 6-10, or all of the inputs, so that the unit can be used as two separate five-input mixers or one ten-input mixer.


VOLTAGE CONTROLLED MIXER MODEL 107
INPUTS
OUTPUTS
1
2
3
4
5
6
7
8
9
10
1-5
all
6-10
1
2
3
4
5
6
7
8
9
10
CBS MUSICAL INSTRUMENTS

Model 107 Voltage-Controlled Mixer

Model 110 Dual Voltage Controlled Gate

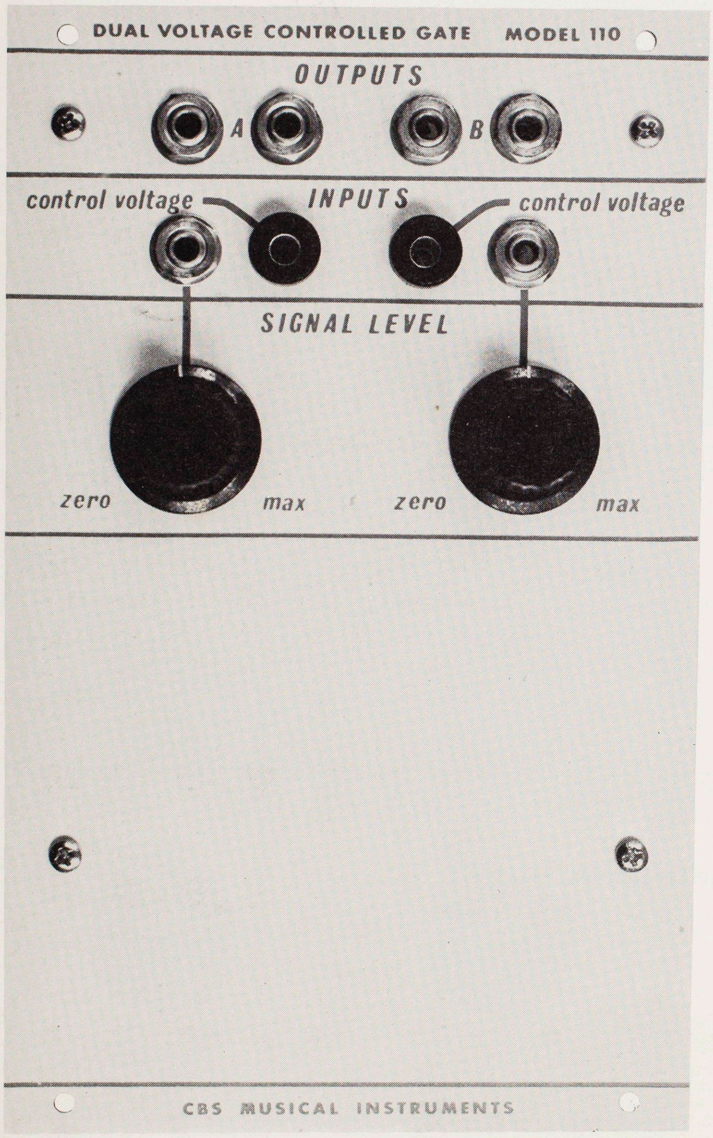
The Model 110 Dual Voltage Controlled Gate is necessary for amplifying **audio signals** according to an externally determined **control voltage.** It has two pairs of **signal inputs** with an associated **control input** and **signal level control** and two **signal outputs.**

The **control input** to the Model 110 Dual Voltage Controlled gate generally comes from a **Model 180 Dual Attack Generator,** in which case the gate is used to process **envelopes.** (See section 7-180.) However, the control input may come from any external device with a control output, and the gate is capable of processing any amplitude-modifying function.

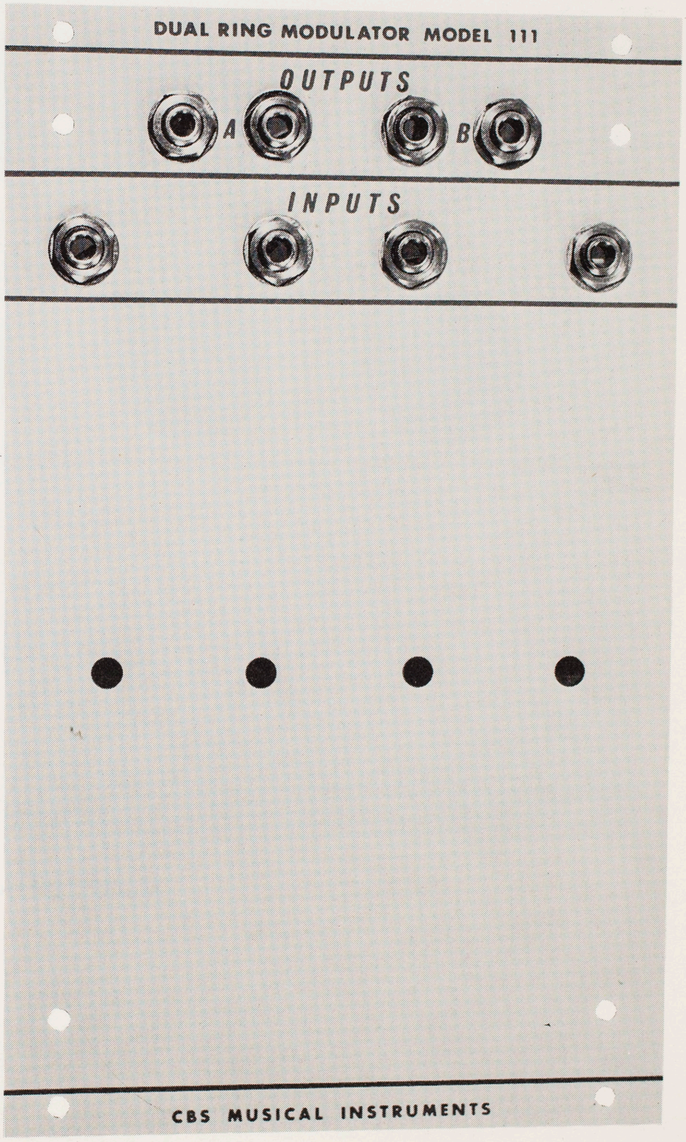
The **signal level control** determines the amplitude of of the output which is processed by the control input.

Model 111 Dual Ring Modulator

Ring modulation is a special kind of amplitude modulation which contains both the same and different frequencies of two input signals. The Model 111 Dual Ring Modulator consists of two independent ring modulators in one panel. Each ring modulator has two **signal inputs** and a pair of **signal outputs.** There are no other controls. It makes no difference which of the two input signals is patched into which input on the panel, as long as both inputs are connected; switching the inputs will result in the same output.


DUAL VOLTAGE CONTROLLED GATE MODEL 110
OUTPUTS
A
B
control voltage
INPUTS
control voltage
SIGNAL LEVEL
zero
max
zero
max
CBS MUSICAL INSTRUMENTS

Model 110 Dual Voltage Controlled Gate


DUAL RING MODULATOR MODEL 111
OUTPUTS
A
B
INPUTS
CBS MUSICAL INSTRUMENTS

Model 111 Dual Ring Modulator

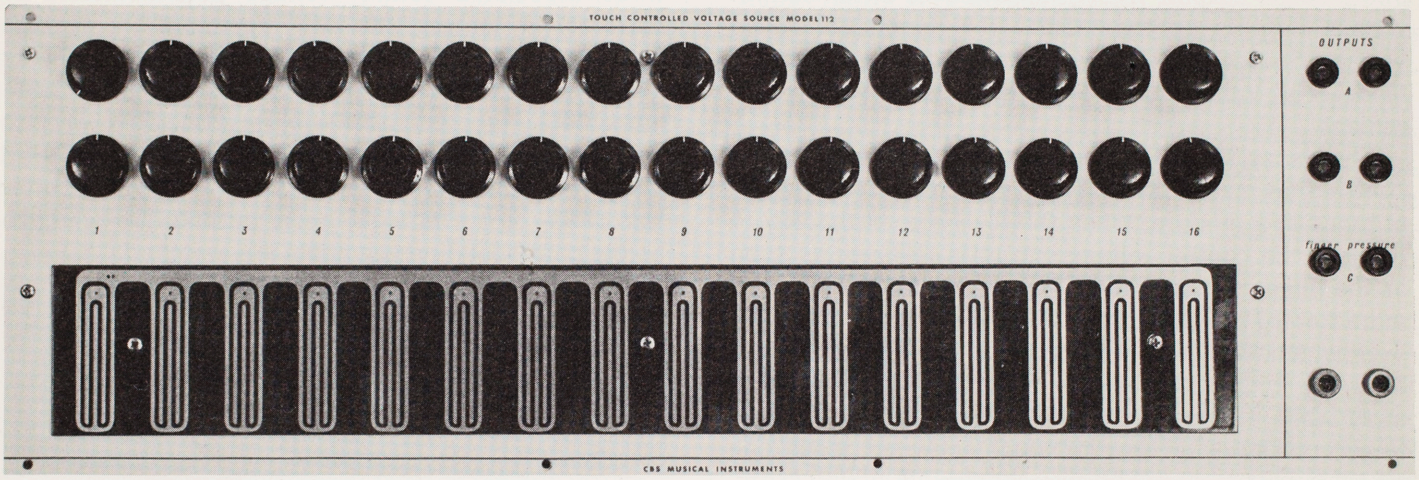
Model 112 Touch Controlled Voltage Source

The Model 112 Touch Controlled Voltage Source is used to initiate **timing pulses** and **control voltages** by manual means. It consists of 16 touch-activated, pressure-sensitive **keys** together with two rows of 16 associated **fixed control voltage dials** and two **control outputs** for each row. There is also a third pair of **control outputs** whose output voltage is proportional to the **finger pressure** on any key, and a fourth pair of **timing pulse outputs.**

The fixed control voltage associated with any key may be determined by the setting on the coresponding dial in either row. Touching a key merely **selects** one of the control voltages in this case.

The value of the control voltage at the third pair of control outputs is proportional to the **finger pressure** on any key. This provides a means of manual dynamic variation of control voltage.

The **timing pulse output** is activated whenever a key is touched. Thus the Model 112 Touch Controlled Voltage Source may be used manually to initiate a note or series of notes with both predetermined and dynamically variable control voltage parameters.

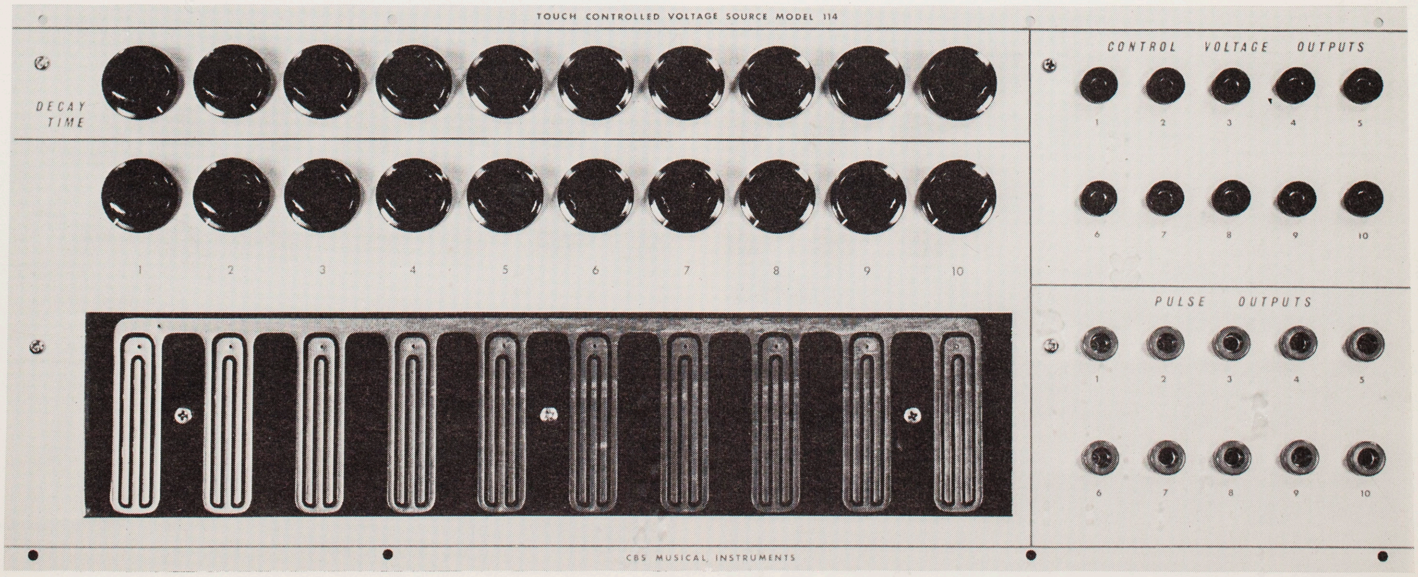

TOUCH CONTROLLED VOLTAGE SOURCE MODEL 112
OUTPUTS
A
B
finger pressure
C
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
CBS MUSICAL INSTRUMENTS

Model 112 Touch Controlled Voltage Source

Model 114 Touch Controlled Voltage Source

The Model 114 Touch Controlled Voltage Source is similar in appearance to the Model 112 Touch Controlled Voltage Source, but it is actually used for very different purposes. It consists of ten pressure-sensitive touch activated **keys** with ten associated **control voltage dials, decay time dials, control voltage outputs,** and **timing pulse outputs.** There are separate control voltage and timing pulse outputs for each key, and each is numbered to indicate the correspondence.

The ten **timing pulse outputs** are activated only when the corresponding key is touched, unlike the Model 112, where the timing pulses are activated when any key is touched. Timing pulses can be used to initiate Model 123 or 146 Sequential Voltage Sources, Model 180 Attack Generators, Model 165 Random Voltage Sources, or Model 140 Timing Pulse Generators.


TOUCH CONTROLLED VOLTAGE SOURCE MODEL 114
DECAY TIME
1
2
3
4
5
6
7
8
9
10
CONTROL VOLTAGE OUTPUTS
1
2
3
4
5
6
7
8
9
10
PULSE OUTPUTS
1
2
3
4
5
6
7
8
9
10
CBS MUSICAL INSTRUMENTS

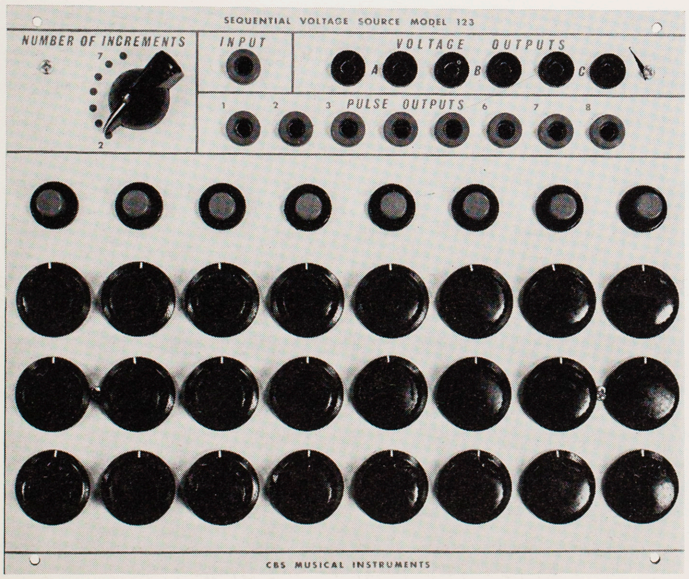
Model 114 Touch Controlled Voltage Source

When the **control voltage dial** for a given key is turned all the way to the left, the control voltage output for that key is determined entirely by finger pressure. When the dial is all the way to the right, the control voltage output is a constant maximum value. At intermediate stages, the control voltage output is a combination of the setting on the dial and finger pressure. This feature of the Model 114 Touch Controlled Voltage Source is particularly useful for controlling Model 110 Voltage Controlled Gates or Model 107 Voltage Controlled Mixers. The keys can then be used to control the amplitudes of a combination of tones which are being mixed into a single output. The correspondence of ten control voltage outputs on the Model 114 Touch Controlled Voltage Source and ten control voltage inputs on the Model 107 Voltage Controlled Mixer is especially convenient.

The **decay time dials** provide an additional level of control that makes possible cross-fading between several tones in a mixture. When the dials are all the way to the left, the control voltage output is released as soon as the finger is taken off the key. As the dials are turned more toward the right, there is an increasing decay time over which the control voltage output drops to zero after the finger is released. Thus, one tone can fade away while another is brought in by slowly increasing finger pressure, or several touch-activated tones can be made to fade away at different rates.

Model 123 Sequential Voltage Source

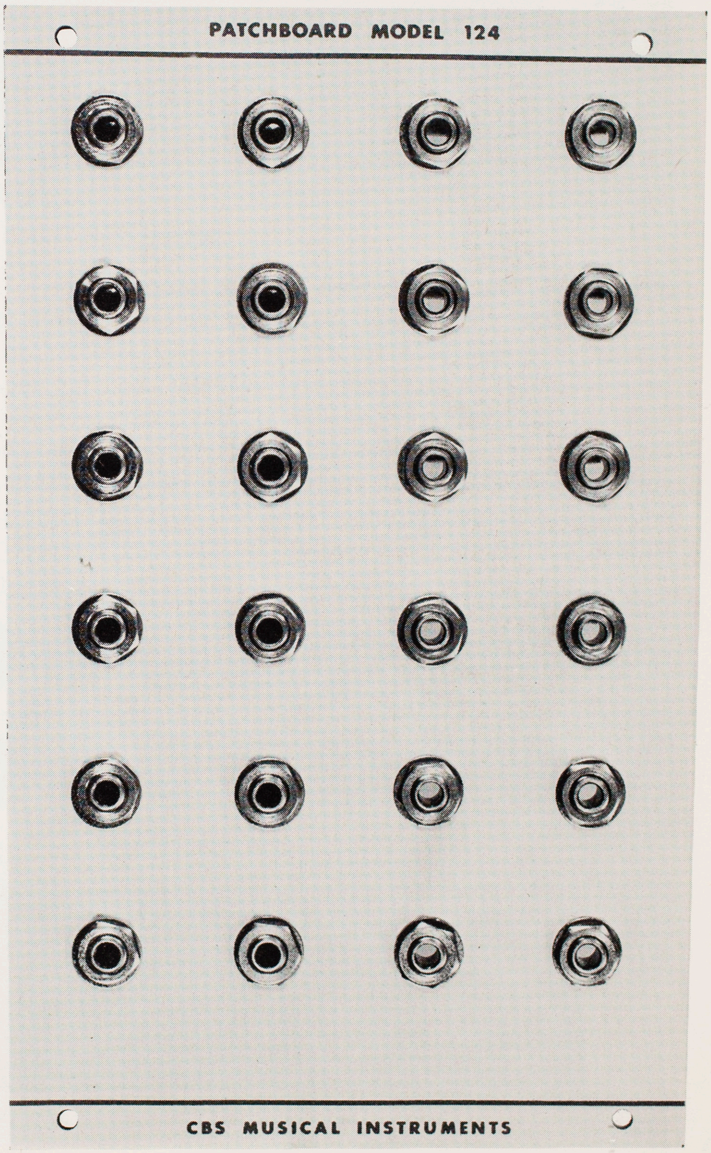
The Model 123 Sequential Voltage Source, one of the most important modules of the Buchla System, produces a repetitive sequence of from two to eight **programmed control voltages** at each of three outputs. Its front panel includes a **timing pulse input,** an **output rotary switch,** three pairs of **control voltage outputs,** eight **timing pulse outputs,** eight red **indicator lamps,** and three rows of eight **control voltage potentiometers.**



Model 123 Sequential Voltage Source

The **timing pulse** input usually comes from a **Model 140 Timing Pulse Generator,** but it may also come from a Touch Controlled Voltage Source. The timing pulse determines **switching** between a **sequence** of between two and eight groups of three **programmed control voltages.** The number of events in the sequence is determined by the **output rotary switch.** Upon receiving a timing pulse, the unit moves to the next group of programmed control voltages. The switching is sequential, so that when it reaches the end of the sequence it returns to the beginning.

The eight red **indicator lamps** show which group of three associated **control voltage potentiometers** are currently in control. The potentiometers are arranged in a 3 x 8 matrix. Each column is associated with a single event, with the corresponding indicator lamp located immediately above. Each row is associated with the same **control voltage output jacks:** the top row feeds jacks "A", the middle row jacks "B" and the bottom row jacks "C". The eight **pulse outputs** are energized as the corresponding segments are switched.



Model 124 Patchboard

Thus, up to three parameters of a repetitive sequence of up to eight notes may be separately and simultaneously controlled. These parameters may correspond, for example, to pitch, amplitude, and duration.

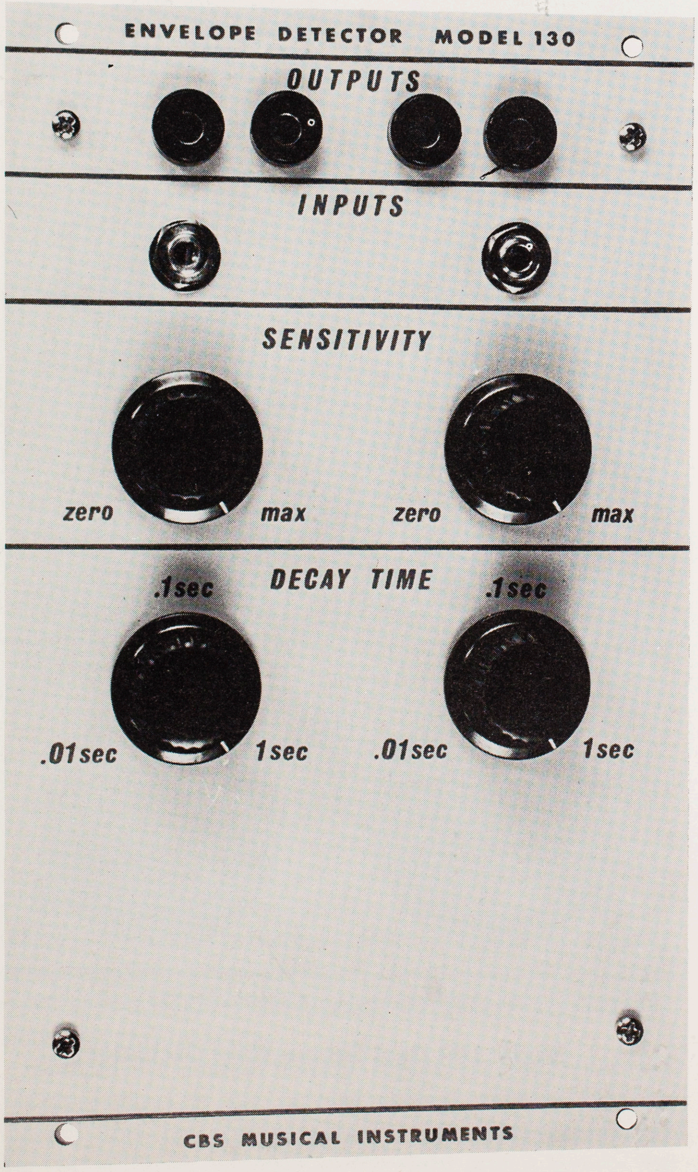
Model 124 Patchboard

Consists of 24 miniature audio jacks mounted on a panel. Used in studio installations to facilitate connection to tape recorders, narrators, and other auxiliary equipment.

Model 130 Dual Envelope Detector

The Model 130 Dual Envelope Detector produces a control voltage proportional to the instantaneous amplitude of an applied signal. In such a way it can reproduce the envelope of an applied "command" signal or perform other general-purpose functions that involve converting an audio signal into a control voltage.

The side of the front panel of the Model 130 Dual Envelope Detector contains an **audio signal input,** a pair of **control voltage outputs,** and dials for the **sensitivity** and **decay time.** The **sensitivity** control determines the proportion of the input signal which the envelope detector will respond to. When it is set at zero, all the way to the left, it will not respond regardless of the amplitude of the input signal. As it is turned more toward the right, the envelope detector will respond to an increasingly softer input signal until, when it is all the way to the right, it will respond to any level input signal. (It is important to remember, however, that its output is still proportional to the input signal, so that a very soft signal will produce a very small value.) Thus, the sensitivity control acts as a threshold device.



Model 130 Dual Envelope Detector

The **decay time dial** provides an additional level of control over the rate at which the control voltage output fades out. When it is all the way to the left, the control voltage is released in exact correspondence with the amplitude of the input signal. When it is moved more toward the right, the release is not instantaneous, but is allowed to fade out over a longer time. The decay time can be varied from .01 to 1 second.

Model 140 Timing Pulse Generator

The Model 140 Timing Pulse Generator is used to initiate **timing pulses** in various ways. Its front panel has two **timing pulse outputs** for **all pulses** and two for **alternate pulses,** two **control voltage inputs** for the **pulse length** and **period,** two **timing pulse inputs** for the **start-stop mode,** a three-position **rotary switch,** a **push button, pulse length** and **period** (tempo) controls, and **external-internal switches** for the **pulse length** and **period.**

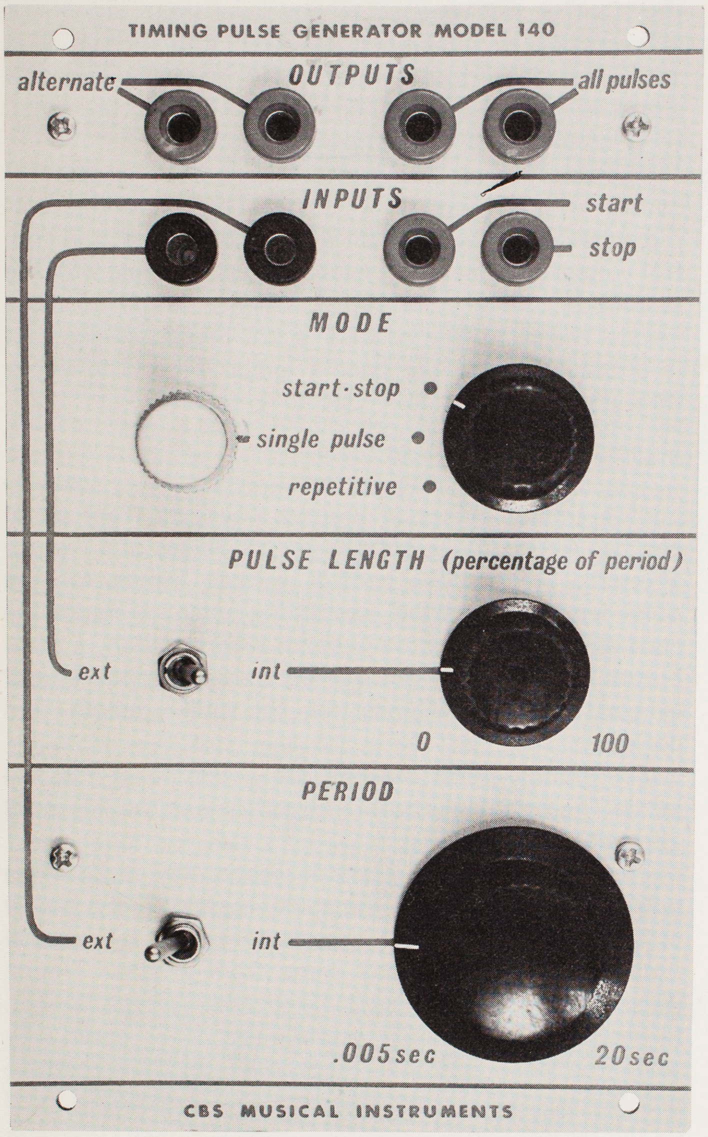
The **timing pulse outputs** are available at the top jacks. The right jacks output all pulses and the left jacks alternate pulses only.

The **mode switch** has three positions: start-stop, **single pulse,** and **repetitive.** In the **start-stop mode,** the action of the Timing Pulse Generator is controlled by **external** timing pulses, which may come from another Timing Pulse Generator or a Touch Controlled Voltage Source. In the single pulse mode, a new pulse is generated only when the **push button** is depressed. In the **repetitive mode,** new pulses are generated at a rate determined by the **period** (tempo) control.

The **period** (tempo) control, if determined internally, will generate a new pulse at a regularly repeating **tempo** between .005 seconds (200 cycles per second) and 20 seconds. The period may also be controlled **externally** by a **control voltage.** If it is desired to use, for example, one of the control voltage outputs of the **Model 123 Sequential Voltage Source** to determine **duration between successive attacks,** it must be patched into this control input. Thus, the Timing Pulse Generator controls and is controlled by the Sequential Voltage Source.

The **pulse length** is always determined as a **percentage** of the **period,** and may be used to control the duration on a **Model 180 Dual Attack Generator.** (See section 7-180.) If determined **internally,** the pulse length may be set to a constant between 0 and 100 per cent. It may also be determined **externally** by a **control voltage.**

The Model 140 Timing Pulse Generator is usually used to control either a Model 123 Sequential Voltage Source or a Model 165 Dual Random Voltage Source, or both, and a Model 180 Dual Attack Generator simultaneously.


TIMING PULSE GENERATOR MODEL 140
alternate
OUTPUTS
all pulses
INPUTS
start
stop
MODE
start-stop
single pulse
repetitive
PULSE LENGTH (percentage of period)
ext
int
0
100
PERIOD
ext
int
.005 sec
20 sec
CBS MUSICAL INSTRUMENTS

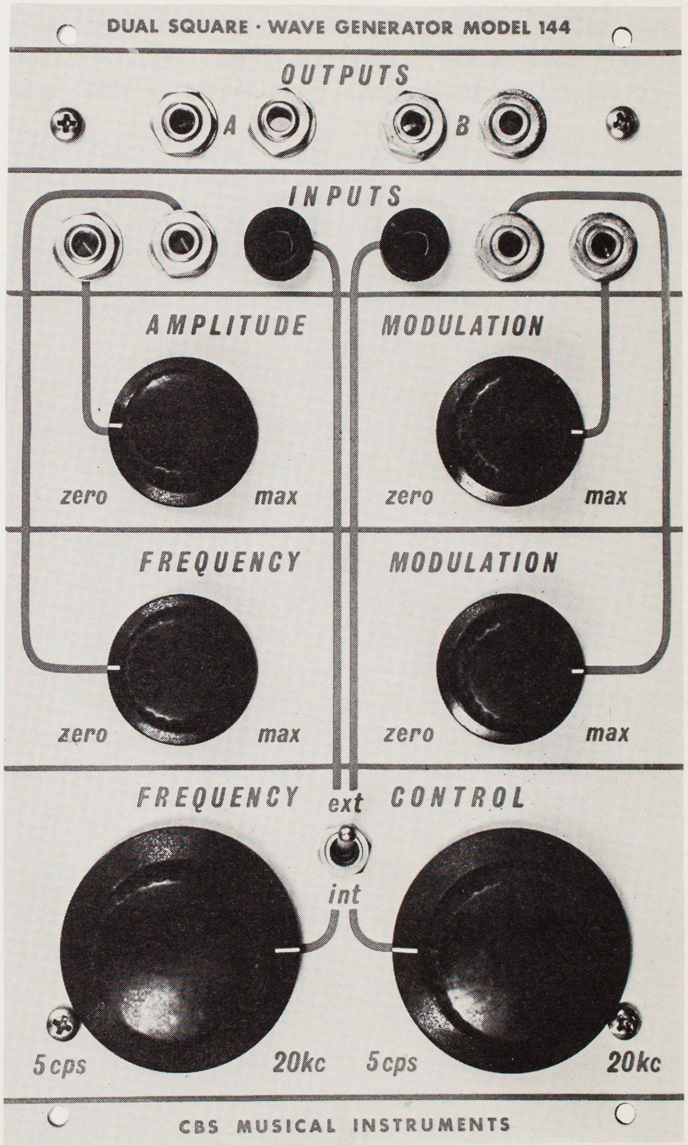
Model 140 Timing Pulse Generator

Model 144 Dual Square Wave Oscillator

The Model 144 Dual Square Wave Oscillator is a basic signal generating module of the Buchla System. Each oscillator contains two **signal outputs,** a **control voltage input,** an **amplitude modulation control** with an associated **signal input,** a **frequency modulation control** with an associated **signal input,** and a **frequency control** dial. There is also an **internal-external switch** which allows the frequencies of both oscillators to be determined by external **control voltages.** Frequencies are continuously variable between 5 and 20,000 cycles per second.

The **frequency modulation** (vibrato) and **amplitude modulation** (tremolo) controls allow the signal output to be varied. Both controls require an external **signal input** (usually from another oscillator), which determines the **rate** (speed) of modulation. The control dial determines the **bandwidth** (amplitude of the modulation, and is continuously variable between zero and the maximum amount of the input signal. This is one of the few cases in the Buchla System where a **signal** is used to determine an aspect of an instrument's operating characteristics.

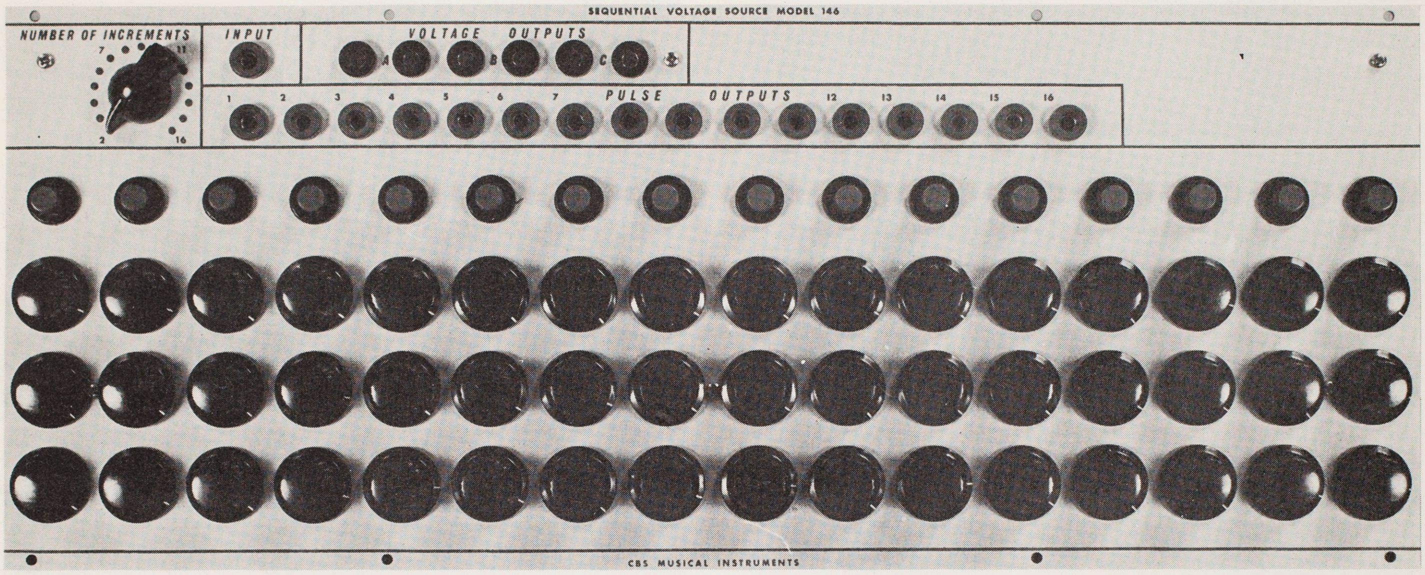
It is a curious feature of the Buchla System that only the square wave oscillators have amplitude modulation controls (cf. section 7-158).


DUAL SQUARE · WAVE GENERATOR MODEL 144
OUTPUTS
A
B
INPUTS
AMPLITUDE
MODULATION
zero
max
zero
max
FREQUENCY
MODULATION
zero
max
zero
max
FREQUENCY
ext
CONTROL
int
5 cps
20kc
5 cps
20kc
CBS MUSICAL INSTRUMENTS

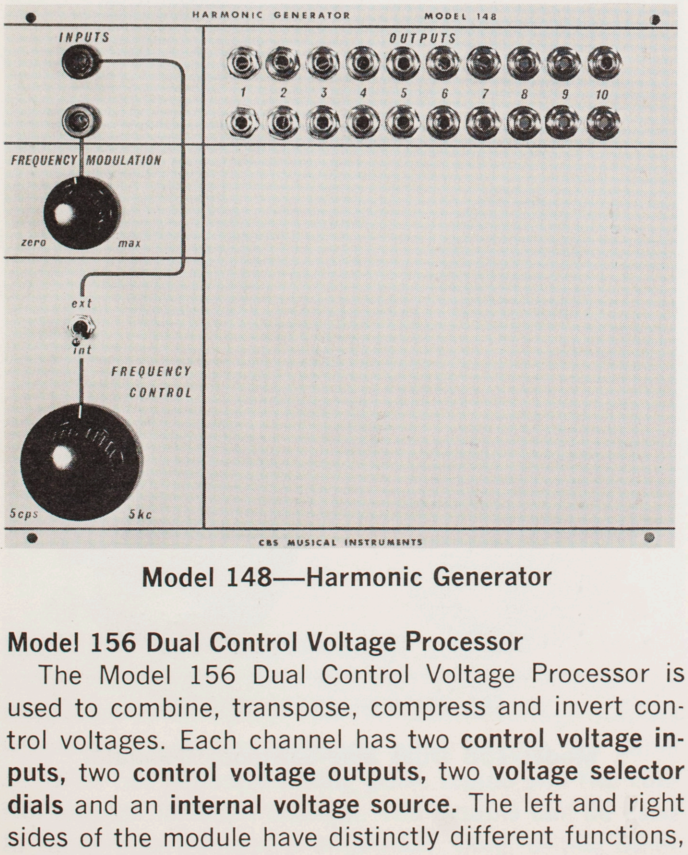
Model 144 Dual Square Wave Oscillator

Model 146 Sequential Voltage Source

The Model 146 Sequential Voltage Source is identical to the Model 123 Sequential Voltage Source, except that it has sixteen groups of three control voltage outputs and sixteen timing pulse outputs instead of eight. For this reason it takes up twice as much panel space as the Model 123 Sequential Voltage Source, but in all other respects it is identical.


SEQUENTIAL VOLTAGE SOURCE MODEL 146
NUMBER OF INCREMENTS
7
11
2
16
INPUT
VOLTAGE OUTPUTS
A
B
C
1
2
3
4
5
6
7
PULSE OUTPUTS
12
13
14
15
16
CBS MUSICAL INSTRUMENTS

Model 146 Sequential Voltage Source


HARMONIC GENERATOR
MODEL 148
INPUTS
OUTPUTS
1
2
3
4
5
6
7
8
9
10
FREQUENCY MODULATION
zero
max
ext
int
FREQUENCY CONTROL
5cps
5kc
CBS MUSICAL INSTRUMENTS

Model 148—Harmonic Generator

Model 156 Dual Control Voltage Processor

The Model 156 Dual Control Voltage Processor is used to combine, transpose, compress and invert control voltages. Each channel has two **control voltage inputs,** two **control voltage outputs,** two **voltage selector dials** and an **internal voltage source.** The left and right sides of the module have distinctly different functions, unlike most dual units.

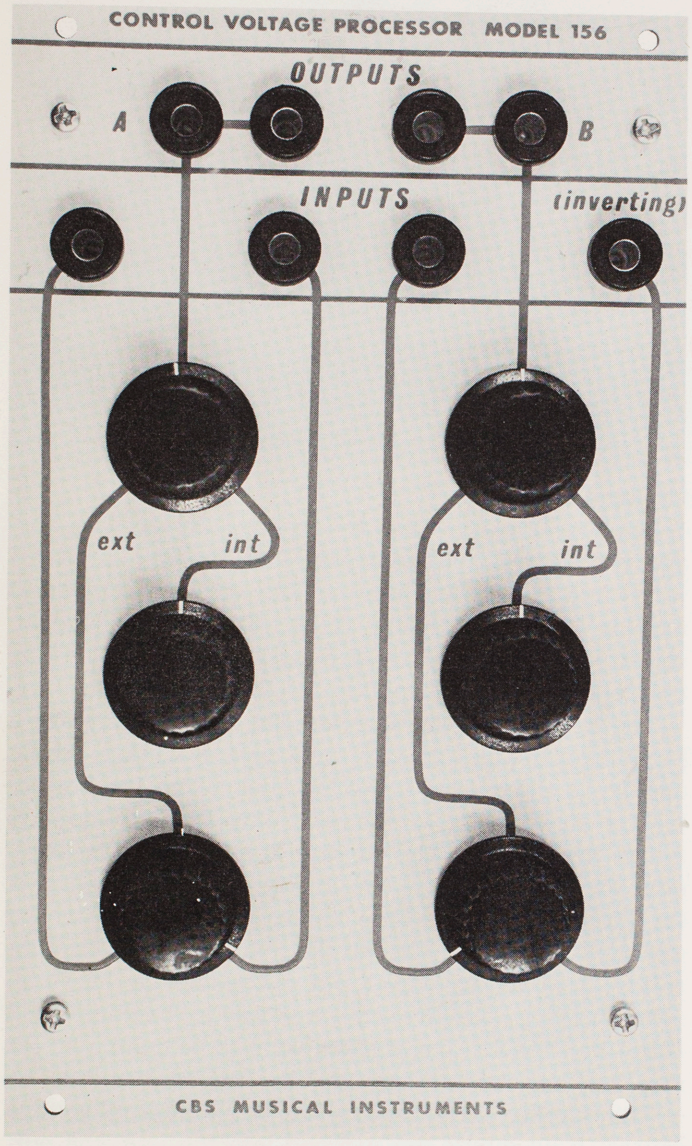
Both of the **control voltage inputs** (in each channel) are connected to the bottom **voltage selector dial.** In the **left** unit, the voltage selector dial simply **combines** the two voltages, whereas in the **right** unit it **inverts** the voltage at the **right** input, such that the maximum voltage (15 volts) is transformed into the minimum (.5 volts) and vice-versa. Intermediate values are inverted modulo 14.5 (+.5) volts. (E. g., 6 volts would be inverted into 14.5 (+.5) —6 (—.5) = 9.5 volts.) Thus, frequency is inverted modulo 20,000 (—5) c.p.s.

The bottom **voltage selector dial** simply **combines** a proportion of the left and right control voltage inputs and feeds the result to the top dial. When the bottom dial is all the way to the left, only the left input is fed to the top dial, and when it is all the way to right, only the right input is fed to the top dial. When it is set at some intermediate value, some proportion of each input is fed to the top dial, so that the maximum voltage that it could ever put out would be 15 volts. (Thus, setting the dial exactly half way in the middle will cause **half** the voltage of each input to be combined (or inverted) and fed to the top dial.)

The **middle** dial sets the value of the **internal voltage source.** If no inputs are patched into the unit, the output will simply be this value, so that the unit may be used as a separate fixed voltage source.

The top **voltage selector dial** determines what proportion of the combined inputs and the internal voltage source is fed to the outputs. When it is set all the way to the left, only the inputs are fed to the ouput, and when it is set all the way to the right, only the internal voltage source is fed to the output. Intermediate values determine what **proportion** of these two sources is fed to the output, so that when it is more to the right, a greater proportion of the internal voltage source is fed to the output, and when it is more to the left, a greater proportion of the inputs is fed to the output. Thus, turning the dial toward the right gradually **compresses the** voltages until they are equal to the internal voltage source. When the top dial is set at some intermediate value, the **internal voltage source** can be used to **transpose** the combined inputs up or down uniformly.

Thus, both units can be used to **transpose, compress,** and **combine** control voltages, and the right unit can be used to **invert** control voltages as well.


CONTROL VOLTAGE PROCESSOR MODEL 156
OUTPUTS
A
B
INPUTS
(inverting)
ext
int
ext
int
CBS MUSICAL INSTRUMENTS

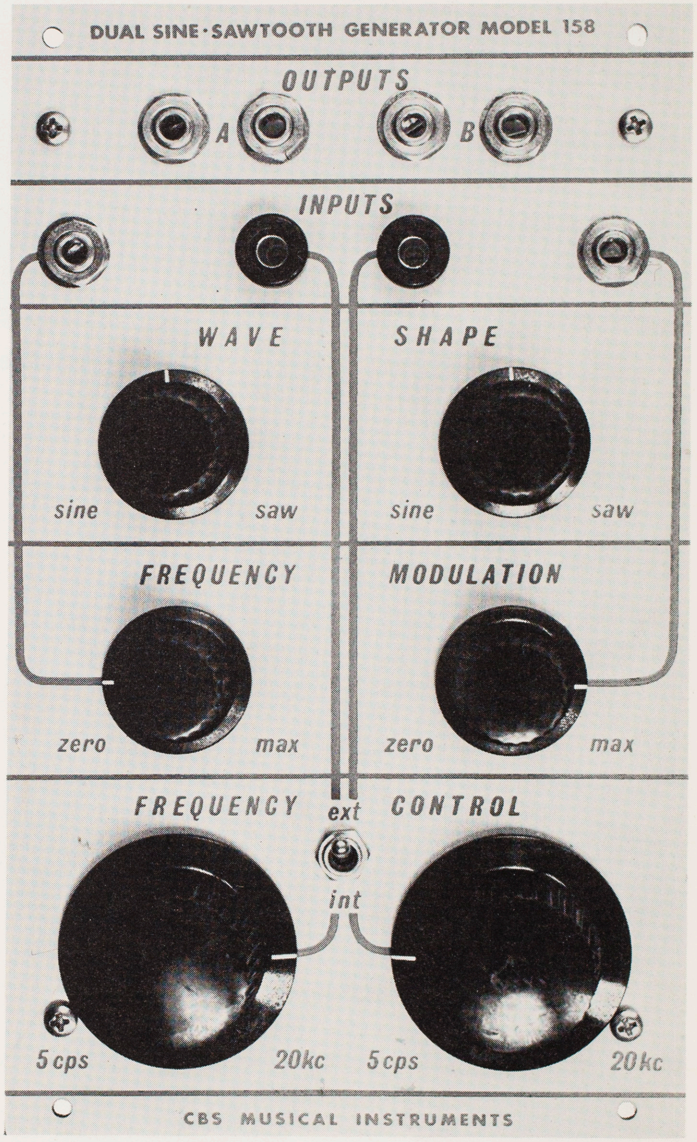
Model 156 Dual Control Voltage Processor

Model 158 Dual Sine-Sawtooth Oscillator

The Model 158 Dual Sine-Sowtooth Oscillator is similar in appearance to the Model 144 Dual Square Wave Oscillator. Each oscillator contains two **signal outputs,** a **control voltage input,** a **wave shape control,** a **frequency modulation control** with an associated signal input, and a **frequency control dial.** There is also an **internal-external switch** which affects both oscillators, allowing their frequencies to be determined by an external control voltage. Frequencies are continuously variable between 5 and 20,000 cycles per second.

The **wave shape control** allows the **waveform** of the output to be continuously varied between a **sine** wave and a **sawtooth** wave. When it is all the way to the left, the oscillator produces a sine wave, and turning it to the right gradually introduces upper partials until the full sawtooth wave is reached.

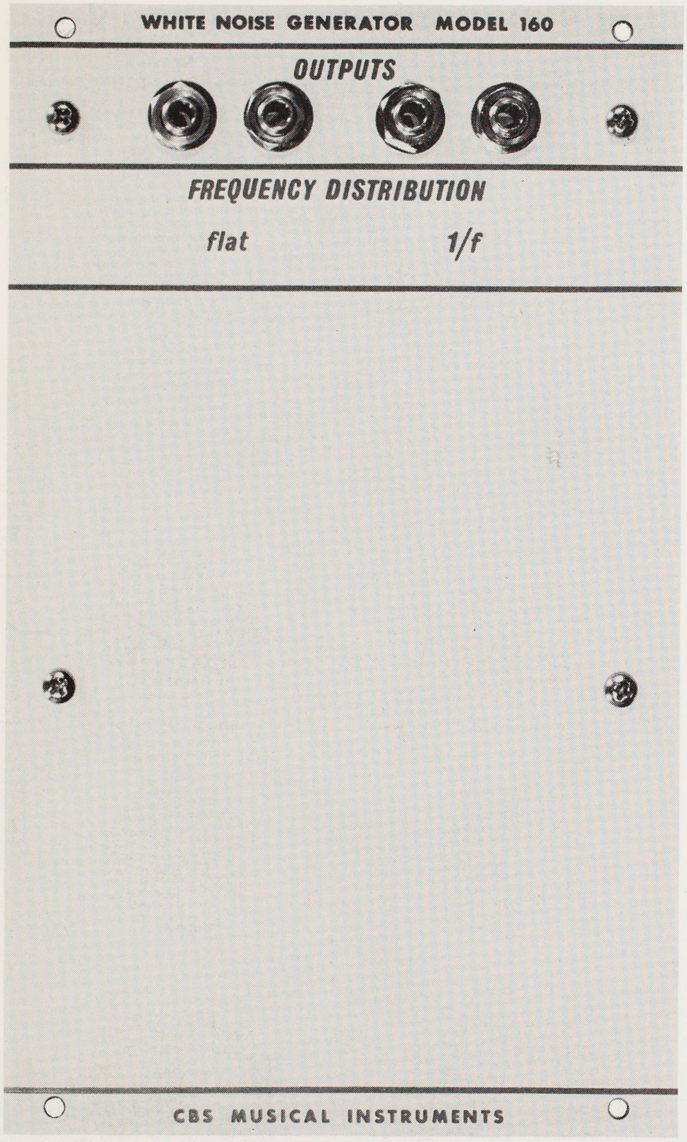
The frequency modulation control requires an external **signal input,** which determines the **rate** (speed) of frequency modulation (vibrato), while the control itself determines the **bandwidth** (amplitude), and may be continuously varied between zero and the full frequency value of the signal input (cf. section 7-144.).


DUAL SINE·SAWTOOTH GENERATOR MODEL 158
OUTPUTS
A
B
INPUTS
WAVE
SHAPE
sine
saw
sine
saw
FREQUENCY
MODULATION
zero
max
zero
max
FREQUENCY
ext
CONTROL
int
5 cps
20kc
5 cps
20kc
CBS MUSICAL INSTRUMENTS

Model 158 Dual Sine-Sawtooth Oscillator

Model 160 White Noise Generator

The Model 160 White Noise Generator produces **white noise** with a flat frequency distribution from 5 to 20,000 cycles per second and weighted noise with a constant power per octave distribution. Its front panel contains two **signal outputs.**

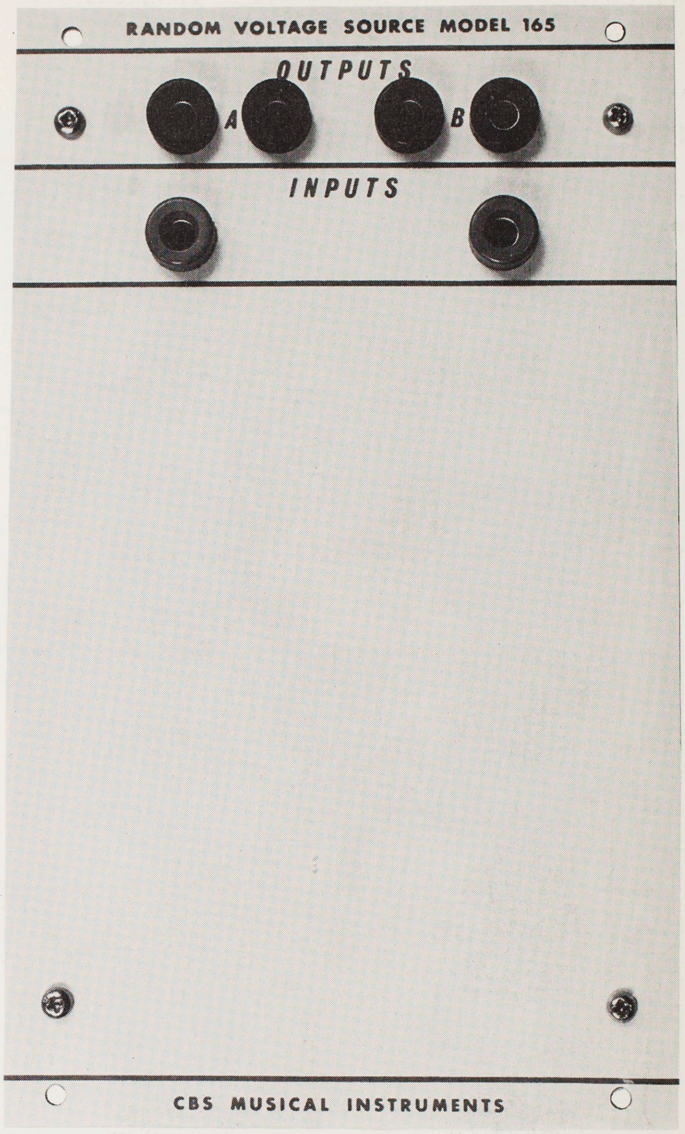


Model 160 White Noise Generator

Model 165 Dual Random Voltage Source

The Model 165 Dual Random Voltage Source produces two uncorrelated, random **control voltage** outputs whenever it receives a **timing pulse** trigger. Its panel contains two separate **timing pulse inputs** and two **control outputs** for each channel. The module can be used to randomize frequency, amplitude, time, or any other parameter determined by a control voltage.

(Note: this unit produces a "click" whenever it receives the timing pulse trigger, which signifies that it has generated a new random voltage. This click is not part of the output and does not affect the signal in any way.)



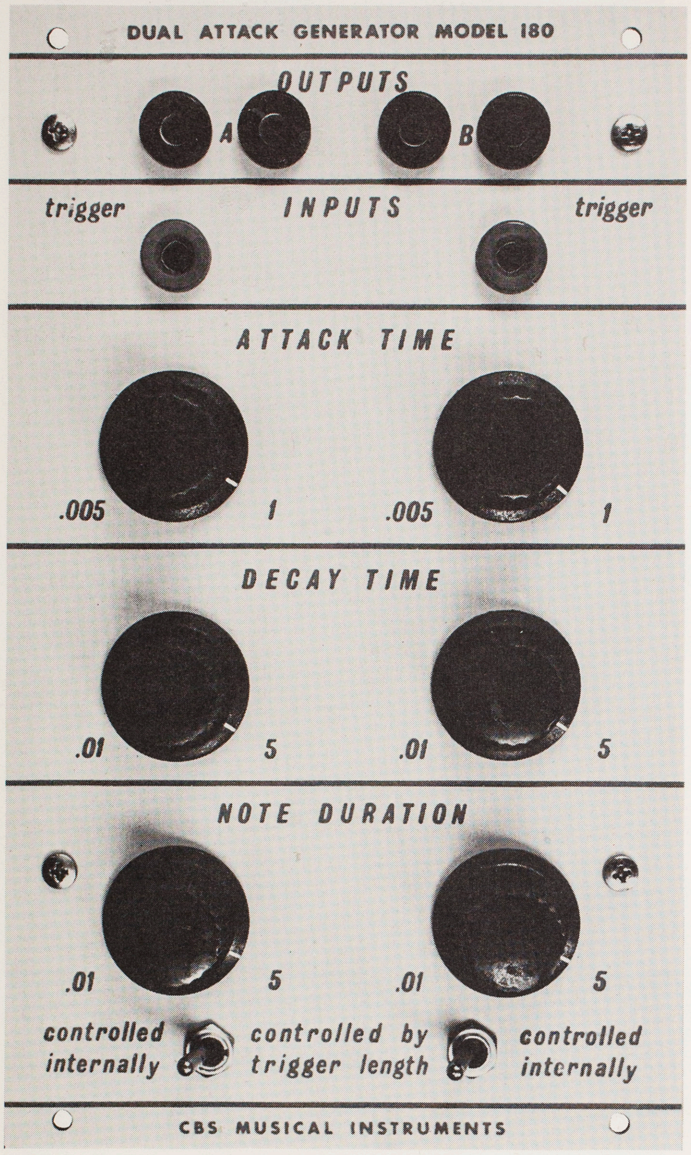
Model 165 Dual Random Voltage Source

Model 180 Dual Attack Generator

The Model 180 Dual Attack Generator produces an **envelope control voltage** initiated by a **timing pulse.** The two units in its panel are entirely separate. Each Attack Generator has two **control voltage** outputs, a **trigger** (timing pulse) **input,** separate controls for **attack time, decay time,** and **note duration,** and an **external-internal** switch which allows the **note duration** to be determined by the **trigger length.**

The **timing pulse** is initiated either by a Model 140 Timing Pulse Generator or a Touch Controlled Voltage Source. The **attack time** is variable from .002 to 1 second; **decay time** from .002 to 5 seconds; **duration** from .002 to 5 seconds. The **mode** of attack and decay is assumed to be **exponential.**

Since the output of the Model 180 Dual Attack Generator is a **control voltage,** it must be used together with a Model 110 Dual Voltage Controlled Gate to apply the envelope to a **signal.** Of course, the unit can also be used to control any parameter, such as frequency, directly.


DUAL ATTACK GENERATOR MODEL 180
OUTPUTS
A
B
trigger
INPUTS
trigger
ATTACK TIME
.005
1
.005
1
DECAY TIME
.01
5
.01
5
NOTE DURATION
.01
5
.01
5
controlled internally
controlled by trigger length
controlled internally
CBS MUSICAL INSTRUMENTS

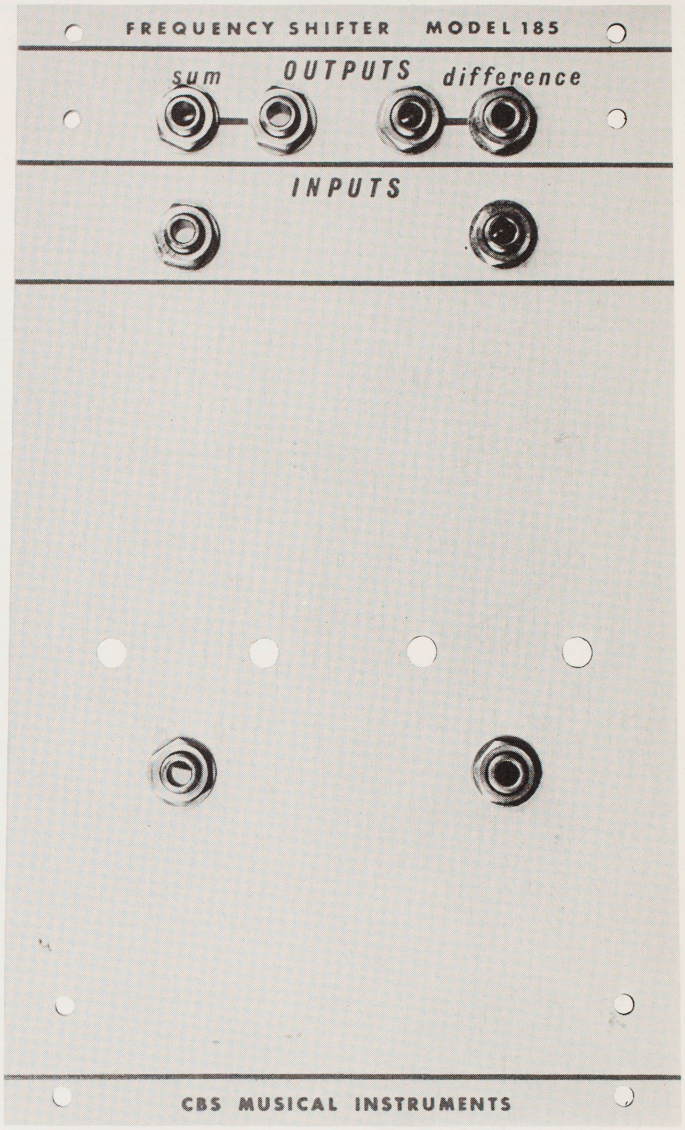
Model 180 Dual Attack Generator

Model 185 Frequency Shifter

The Model 185 Frequency Shifter is used to shift frequencies of an input signal by an amount determined by another applied carrier frequency. The shifting is applied uniformly to all frequencies in the input signal, so that the unit is not a **transposing** device, but a device for obtaining new **timbres,** usually containing **non-harmonic partials.**

The front panel of the Model 185 Frequency Shifter contains two **signal inputs** and four **signal outputs,** two of which are marked "sum" and two of which are marked " difference". The left signal input is for the **signal** and the right is for the **carrier frequency.** In the **sum outputs** the carrier frequency is **added** to the frequencies of the input signal, and in the **difference outputs** the carrier frequency is **subtracted** from the input signal. In the case of the difference outputs only, **negative frequencies** may be present and audible. In the case of sum outputs, frequencies shifted above the limits of audibility will simply be lost.

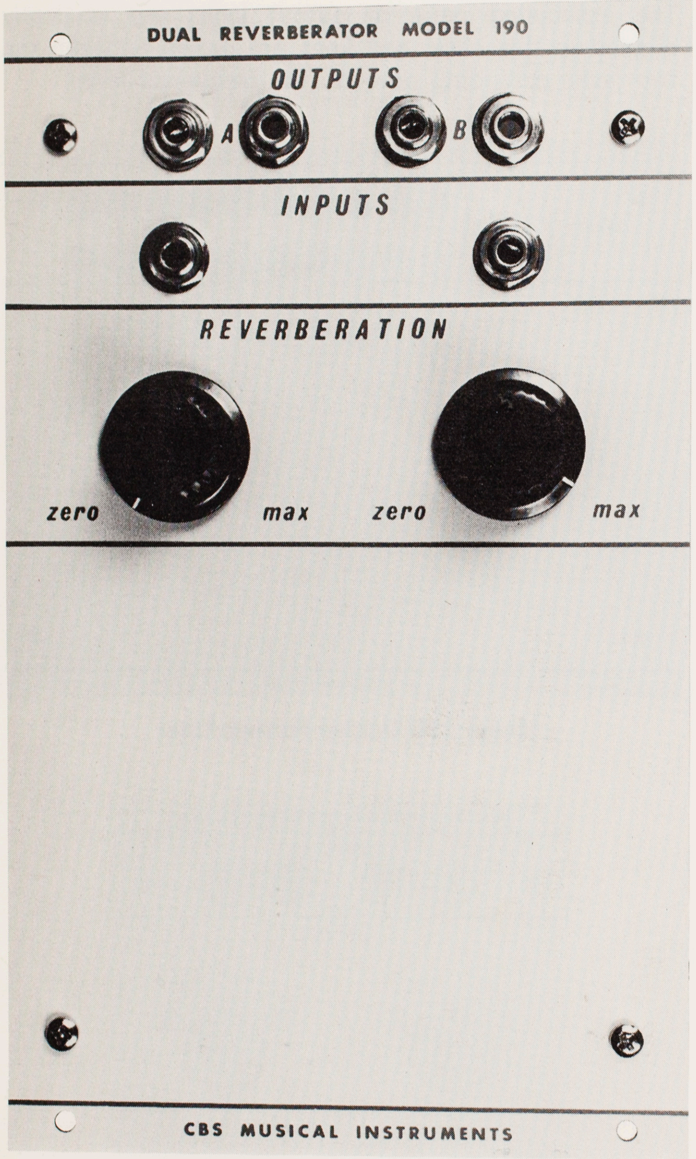
If the **sum** and **difference** outputs are **mixed** into one signal, the Model 185 Frequency Shifter produces **ring modulation.**


FREQUENCY SHIFTER MODEL 185
sum
OUTPUTS
difference
INPUTS
CBS MUSICAL INSTRUMENTS

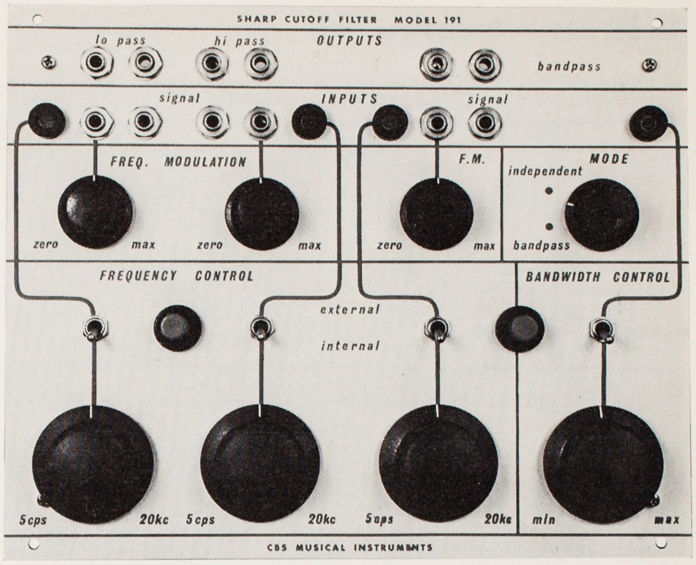
Model 185 Frequency Shifter

Model 190 Dual Reverberation Unit

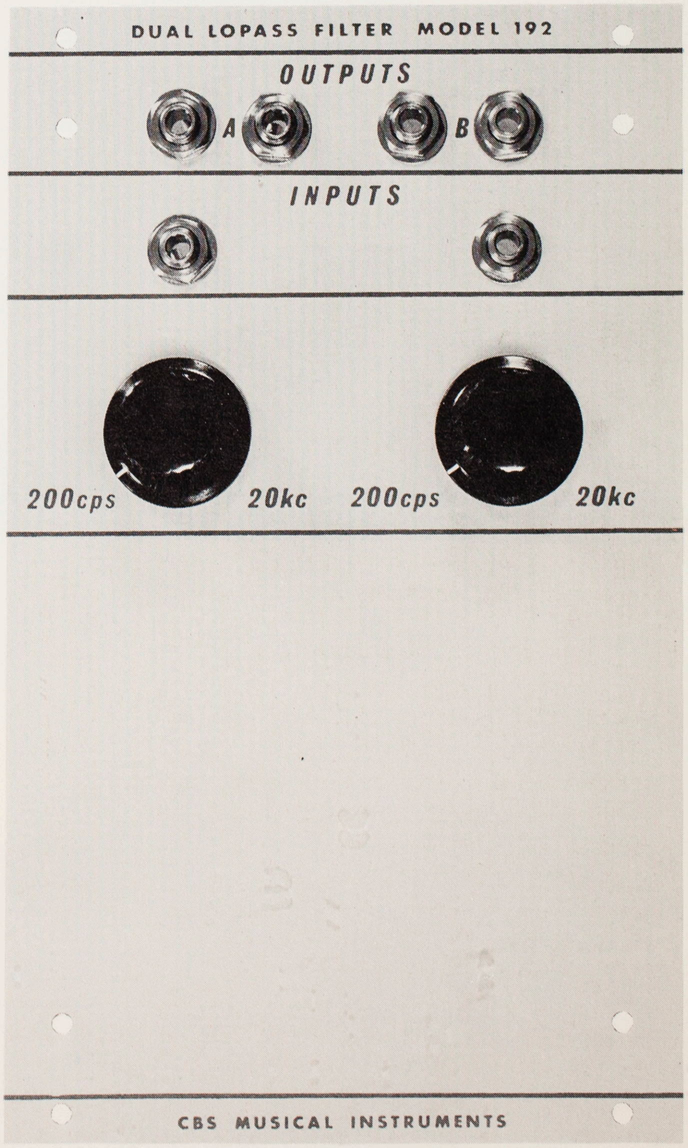
The Model 190 Dual Reverberation Unit contains two independent spring type reverberators. Each reverberator contains a **signal input,** two **signal outputs,** and a **reverberation control dial.** The degree of reverberation is continuously variable by the reverberation control dial.


DUAL REVERBERATOR MODEL 190
OUTPUTS
A
B
INPUTS
REVERBERATION
zero
max
zero
max
CBS MUSICAL INSTRUMENTS

Model 190 Dual Reverberation Unit

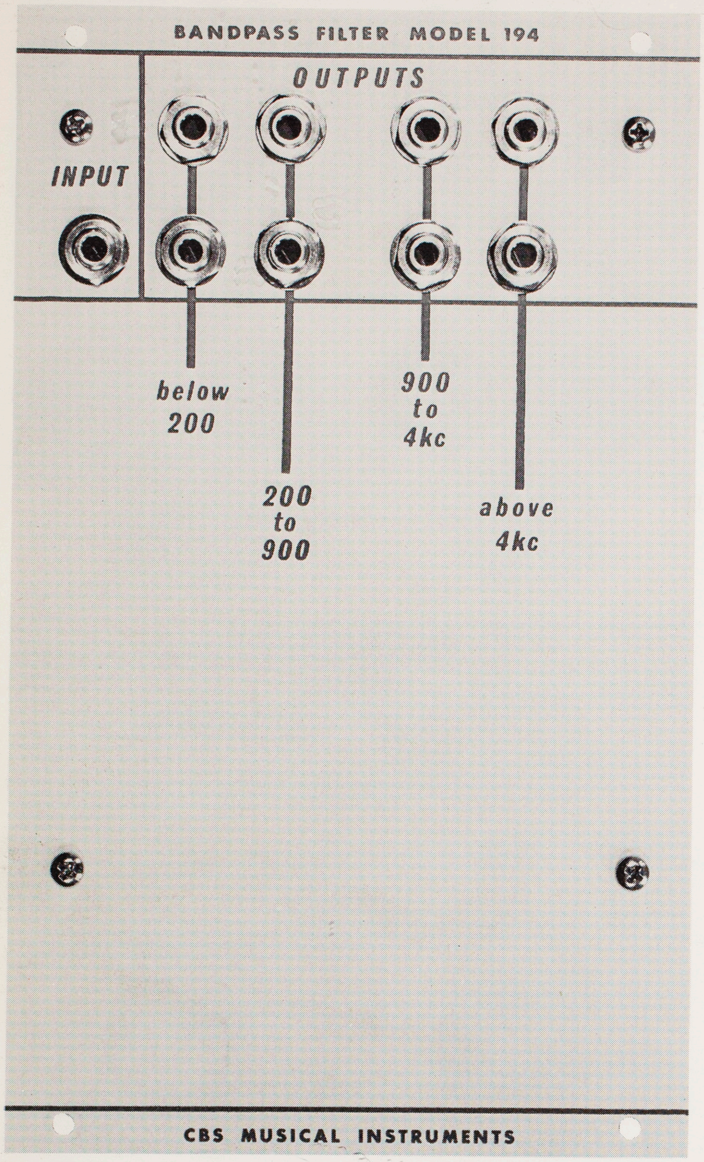

SHARP CUTOFF FILTER MODEL 191
lo pass
hi pass
OUTPUTS
bandpass
signal
INPUTS
signal
FREQ. MODULATION
zero
max
zero
max
F.M.
zero
max
MODE
independent
bandpass
FREQUENCY CONTROL
BANDWIDTH CONTROL
external
internal
5cps
20kc
5cps
20kc
5cps
20kc
min
max
CBS MUSICAL INSTRUMENTS

Model 191 — Sharp Cutoff Filter


DUAL LOPASS FILTER MODEL 192
OUTPUTS
A
B
INPUTS
200cps
20kc
200cps
20kc
CBS MUSICAL INSTRUMENTS

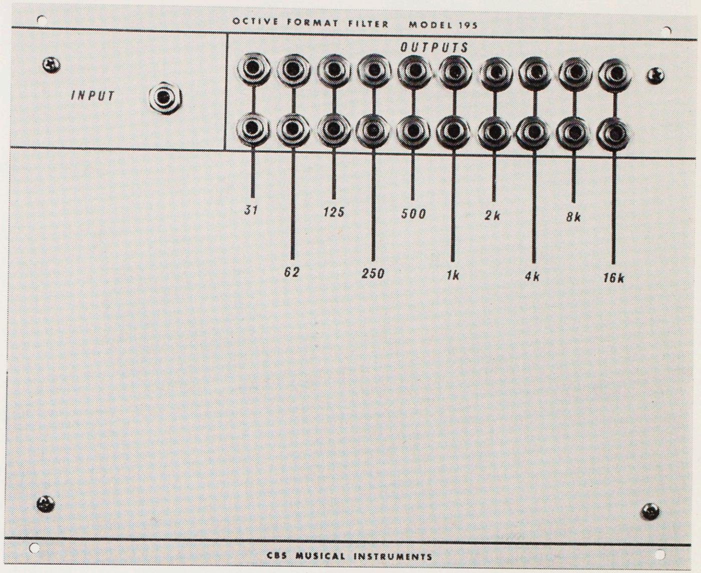
Model 192—Dual Lopass Filter

Model 194 — Band Pass Filter

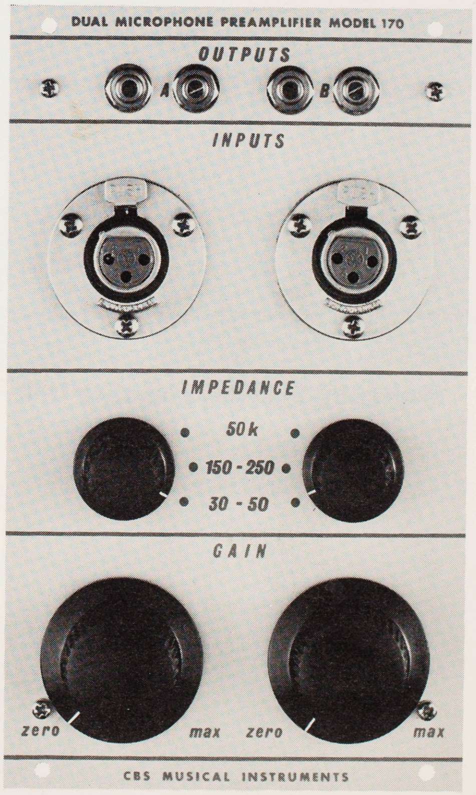

BANDPASS FILTER MODEL 194
OUTPUTS
INPUT
below 200
200 to 900
900 to 4kc
above 4kc
CBS MUSICAL INSTRUMENTS

Model 195 Octave Format Filter

The Model 195 Octave Format Filter divides one input signal into ten frequency bands centered at octave intervals from 31 cps to 16 kc. Its front panel contains one **audio signal input** and ten pairs of **audio signal** outputs of frequency bands centered at 31, 62, 125, 250, 500, 1k, 2k, 4k, 8k, and 16k cycles per second. The associated pairs of output jacks are vertically aligned in this case, and lines are drawn between the two jacks extending down to the frequency label.


OCTIVE FORMAT FILTER MODEL 195
OUTPUTS
INPUT
31
62
125
250
500
1k
2k
4k
8k
16k
CBS MUSICAL INSTRUMENTS

Model 195 Octave Format Filter


DUAL MICROPHONE PREAMPLIFIER MODEL 170
OUTPUTS
A
B
INPUTS
IMPEDANCE
50k
150 - 250
30 - 50
GAIN
zero
max
zero
max
CBS MUSICAL INSTRUMENTS

Model 170 — Dual Microphone Preamplifier

Educational Research Department,
CBS Musical Instruments, Columbia
Broadcasting System Inc., 1300 E.
Valencia, Fullerton, California 92631.

CBS MUSICAL
INSTRUMENTS

BUCHLA
ELECTRONIC
MUSIC SYSTEM

COMPLETE
SYSTEMS
NOVEMBER 1, 1969

The following systems are presented as examples of complete, well-balanced Modular Electronic Music Systems:

Buchla Electronic Music System No. 1

A single super-module consisting of the following components:

1 Model 101 Cabinet
2 Model 106 Mixers
1 Model 110 Dual Voltage Controlled Gate
1 Model 111 Dual Ring Modulator
1 Model 112 Touch Controlled Voltage Source
1 Model 115 Power Supply
1 Model 124 Patchboard
1 Model 140 Timing Pulse Generator
1 Model 144 Square Wave Oscillator
1 Model 146 Sequential Voltage Source
1 Model 156 Dual Control Voltage Processor
3 Model 158 Dual Sine-Sawtooth Oscillators
1 Model 160 White Noise Generator
1 Model 170 Dual Microphone Preamplifier
1 Model 180 Dual Attack Generator
1 Model 190 Dual Reverberation Unit
1 Model 194 Bandpass Filter
1 Patch Cord Set

CBS MUSICAL
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BUCHLA
ELECTRONIC
MUSIC SYSTEM

COMPLETE
SYSTEMS
NOVEMBER 1, 1969

Buchla Electronic Music System No. 2

Two super-modules consisting of the following components:

2 Model 101 Cabinets
4 Model 106 Mixers
1 Model 107 Voltage Controlled Mixer
2 Model 110 Dual Voltage Controlled Gates
1 Model 111 Dual Ring Modulator
2 Model 112 Touch Controlled Voltage Sources
1 Model 114 Touch Controlled Voltage Source
2 Model 115 Power Supplies
1 Model 123 Sequential Voltage Source
1 Model 124 Patchboard
1 Model 130 Dual Envelope Detector
2 Model 140 Timing Pulse Generators
1 Model 144 Square Wave Oscillator
1 Model 146 Sequential Voltage Source
2 Model 156 Dual Control Voltage Processors
4 Model 158 Dual Sine-Sawtooth Oscillators
1 Model 160 White Noise Generator
1 Model 165 Dual Random Voltage Source
1 Model 170 Dual Microphone Preamplifier
1 Model 175 Dual Equalizer Line-Driver
2 Model 180 Dual Attack Generators
1 Model 190 Dual Reverberation Unit
1 Model 191 Sharp Cutoff Filter
1 Model 194 Bandpass Filter
2 Patch Cord Sets

CBS MUSICAL
INSTRUMENTS

BUCHLA
ELECTRONIC
MUSIC SYSTEMS

PRICE
INFORMATION
NOVEMBER 1, 1969

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*NOTE:
The numbers in the "Panel Units" column indicate the relative space occupied in the cabinet by the corresponding modules. Total the number of panel units desired in a system and order one power supply (115), one cabinet (101), and one patch cord set for each 25 (or portion thereof) panel units.

Model No.	Panel* Units	Description	Single Module Price
101-1	0	Cabinet - System 1	$ 180.
101-2	0	Cabinet - System 2	360.
106	1	Mixer	75.
107	2	Voltage Controlled Mixer	350.
110	1	Dual Voltage Controlled Gate	100.
111	1	Dual Ring Modulator	165.
112	5	Touch Controlled Voltage Source	375.
114	4	Touch Controlled Voltage Source	310.
115	0	Power Supply	100.
123	2	Sequential Voltage Source	280.
124	1	Patchboard	35.
130	1	Dual Envelope Detector	135.
140	1	Timing Pulse Generator	150.
144	1	Dual Square Wave Oscillator	190.
146	4	Sequential Voltage Source	460.
148	2	Harmonic Generator	950.
150	1	Frequency Counter	550.
156	1	Dual Control Voltage Processor	95.
158	1	Dual Sine-Sawtooth Oscillator	275.
160	1	White Noise Generator	75.
165	1	Dual Random Voltage Source	175.
170	1	Dual Microphone Preamplifier	125.
171	1	Dual Instrument Preamplifier	125.
175	1	Dual Equalizer - Line Driver	165.
180	1	Dual Attack Generator	140.
185	1	Frequency Shifter	420.
190	1	Dual Reverberation Unit	200.
191	2	Sharp Cutoff Filter	450.
192	1	Dual Lopass Filter	140.
194	1	Bandpass Filter	135.
195	2	Octave Format Filter	225.
196	1	Phase Shifter	140.
		Patch Cord Set	65.
		Complete System No. 1	3565.
		Complete System No. 2	7060.

NOTE:
Prices may change resulting from design changes or price increases of material and labor. Firm prices will be acknowledged on request.

SOME BASIC CONCEPTS OF ELECTRONIC MUSIC©

"Electronic Music" is the term generally used to describe any music which involves electronically controlled sound generating or modifying equipment in its production. Thus it includes any [1]music or noises that could be produced by conventional musical instruments or natural phenomenon as well as sounds that can be produced only by electronic means. Before we can begin to understand the vast number of possibilities that are available in this domain we must know some things about the nature of sound itself and the way we hear things.

The most fundamental musical quantity that exists is what we might call a single *tone*. Just one tone has several distinct properties or audible *dimensions* that serve to distinguish it from other tones. These dimensions include things like its *pitch* or *frequency* (its "highness" or "lowness"), its *duration*, its *loudness* or *amplitude*, or other things that are generally grouped together as its *rhythm* (usually in association with other tones), and its *timbre* or *tone color*. These are the most basic qualities we have learned to distinguish among single tones, and any musical instrument or sound generating system must provide a way of controlling each of them separately and at the same time. There are also some other dimensions of sound that we will point out, and if we want to know how these things have been or could be used in music, we must learn to recognize their qualities when we hear them.

Pitch is usually thought of in a musical sense in relation to the twelve-tone *scale*. While we normally take this for granted, we are also aware that there can be finer gradations between each of the intervals, and that some instruments can glide up or down uniformly. *Loudness*, similarly, is usually thought of in only general or relative terms; sounds can be soft or loud, or soft or loud in relation to one another. *Timbre*, on the other hand, is not as widely understood, and needs further explanation.

The most basic kind of sound that exists in nature is called a *sine* tone: it is simply a single tone with no harmonic partials. [2]*Harmonic partials* or *overtones* are other tones with frequencies of 2, 3, 4, or any whole number times the frequency of a given tone or *fundamental* frequency. Harmonic partials are generally not heard as separate tones, but, taken together, constitute the *timbre* of the sound.

It is apparent, then, that most tones within the normal frequency range of music or speech can have overtones that extend quite high above the fundamental frequency. The difference in the tone-color of sounds of the same pitch reduces to the difference in the amplitudes of the harmonic partials. Most musical instruments as well as electronic music generating systems produce complex timbres not by controlling the partials individually, but by a combination of an *input signal* and a *filter*.

There are two basic kinds of input signals in which the amplitude of the harmonic partials bear a simple relationship to one another, and these are generally considered "standard" tones for this reason. A *sawtooth wave* contains *all* the harmonic partials of a given fundamental frequency (theoretically; in practice, as high as we can hear) in the amplitude ratio of 1/n, where n is the number of a harmonic partial. (Thus the second harmonic partial is ½ the amplitude of the first, the third is ⅓, etc.) A *square wave* has the same amplitude ratios as a sawtooth wave, but contains only *odd-numbered* harmonic partials. [3]*White noise*, another kind of basic input signal, contains *all frequencies* from as low to as high as we can hear simultaneously. It sounds like the hiss or static that is usually present as background noise, and is called "white" by analogy with white light, which is a mixture of all colors. (Similarly, "black noise" is sometimes used to refer to silence.)

1. NOISE IS DEFINED AS ANY UNWANTED SOUND OR SIGNAL. (THEREFORE MUSIC [ORGANIZED SOUND IN TIME] SOMETIMES QUALIFIES AS NOISE. A BETTER CHOICE OF TERMS WOULD BE SOUNDS, PERIODIC OR APERIODIC VIBRATIONS.

2. OVERTONE REFERS TO ANY UPPER PARTIAL OF A TONE INCLUDING HARMONICS. UPPER PARTIALS MAY ALSO NOT BE INTEGRAL MULTIPLES OF THE FUNDAMENTAL AND ALSO CONTRIBUTE TO THE TIMBRE OF THE SOUND.

3. WHITE SOUND MAY BE A BETTER TERM IN VIEW OF THE DEFINITION OF NOISE.

4.

ALL THE POSSIBLE FREQUENCIES OF CONTINUOUS A-C WAVES MAKE UP THE FREQUENCY SPECTRUM. IN ELECTRONICS THE FREQUENCY SPECTRUM IS CONSIDERED FROM ABOUT 20 HZ. (OR MUCH SLOWER) TO 30,000 MEGAHZ. (ALTHOUGH THE FREQUENCY SPECTRUM EXTENDS FAR BEYOND) THE FREQUENCY CONTINUUM REFERRED TO HERE SHOULD BE CALLED THE AUDIO FREQUENCY CONTINUUM OR BAND WHICH IS APPROXIMATELY 20 TO 20,000 HZ.

5.

* MODULATION ≡ IS A PROCESS WHEREBY SOME CHARACTERISTIC OF A WAVE (COMMONLY FREQUENCY OR AMPLITUDE) IS VARIED BY ANOTHER WAVE.

* ELECTRONICS 1 - H. MILEAF - HAYDEN PUB.

MODULATION IS THE VARIATION OF ONE PARAMETER IN SYMPATHY WITH ANOTHER PARAMETER.

PARAMETER IS A QUANTITY WHICH CAN BE MEASURED. I.E. FREQUENCY (WHICH CAUSES PITCH AND AMPLITUDE WHICH CAUSES LOUDNESS.)

4.

The operation of a *filter* must be understood in relation to the *frequency continuum*, which is simply the total range of sounds from as low to as high as we can hear. Its operation is to *resonate* (increase) or *attenuate* (decrease) the amplitudes of any frequencies within some particular area of the frequency continuum. Filters can also be used to *pass* or *reject* certain frequencies in entirety.

A *low pass filter* is a filter which cuts off high frequencies, thus *passing* low frequencies. A *high pass filter* is the reverse of a low pass filter, which cuts off low frequencies and passes high frequencies. The frequency at which the attenuation begins is called the *cutoff frequency*.

A *band pass filter* is a filter which resonates only one particular area of the frequency continuum. The midpoint of this area is called the *center frequency*, and the *bandwidth* is the area on each side of the center frequency which is resonated. A *band reject filter* is the reverse of a band pass filter, which rejects one particular frequency area and passes frequencies on each side of that area.

If the input to a filter is a waveform containing a fundamental frequency and its harmonic partials, the filter will affect the timbre of the sound, resonating certain partials and attenuating others. White noise may also be used with a bandpass filter to give it a definite pitch (analogous to the sound "shhh").

Most sounds do not begin and end instantaneously. They take a certain short time to reach their peak amplitude, after which time they may hold for a while and then return to silence before another sound begins. The *attack* and *decay* characteristics of a sound are referred to as its *envelope*. The variables in this case are the *times* that it takes the tone to build up to its full amplitude and return to silence. Another variable, of course, is the *duration* of the tone. No tones produced on musical instruments are without their envelopes, and this characteristic must generally not be overlooked in electronic music either.

Very often the sounds that we hear undergo slight variations in their tonal characteristics while they last. Very few sounds are totally unwavering, and sometimes the amount of variation is extensive. Any periodic change of a characteristic of a sound is called [5.] *modulation*. A periodic change in the *pitch* of a sound is called *vibrato* or *frequency modulation*. A periodic change in the *loudness* of a tone is called *tremolo* or *amplitude modulation*. There are always three variables in any kind of modulation: the *frequency* or rate of modulation; the *amplitude* or amount being varied; and the *shape* or manner in which the variation is being applied. If the frequency of modulation is quite slow, each of the variations can be heard separately; but if the frequency of modulation is faster than approximately 20 cycles per second, the lower limit of perception for pitch, the frequency of modulation will be heard as a separate pitch in itself, and the resulting sound will be quite complex. Modulation is not limited to amplitude and frequency; it can be applied to any dynamic characteristic of a single sound, such as, for example, its timbre, or to any components of a more complicated musical texture, such as the amplitudes of a group of tones being mixed into one sound.

AND SOMETIMES A-PERIODIC
I.E. FREQUENCY MODULATION WITH
WEIGHTED WHITE NOISE

Ring modulation is a special kind of amplitude modulation which contains both the sum and difference frequencies of two input signals. It is mathematically equivalent to multiplying the two signals together. (Adding them together, in comparison, simply mixes them into one sound.)

When all of the harmonic partials of a given fundamental frequency are present in a tone, the only pitch that is heard is the fundamental. The others make up the timbre of the tone. If the partials are shifted up or down, however, and the same interval is maintained between each of them, they will no longer be in a harmonic relation to one another, and they will be heard as independent frequencies. (Suppose, for example, that a sound consists of a fundamental frequency of 100 cps, and overtones of 200, 300, and 400 cps. If the frequencies are shifted to 107, 207, 307, and 407 cps, they will no longer be harmonic partials of 107 cps and they will be heard as separate frequencies.) Since the partials still stand in a simple mathematical relationship to one another, they are called *non-harmonic partials*. This process is called *frequency shifting*. The signal that determines the amount of shifting is called the *carrier frequency*. Since shifting could be either up or down, there is usually provision for *sum* and *difference* outputs. Frequencies shifted below zero cps will return and move higher. If the sum and difference frequencies are mixed together, the result will be *ring modulation*.

When sounds are produced in a normal environment, the sound that reaches the listener's ear does not all come directly from the sound source; some of it comes to him after bouncing off of the walls or other objects. This process adds *reverberation* or *echo* to the sound, and it is normally a product of the musical environment. It can also be produced electronically. Its only variable characteristic is the *reverberation time*, which is the length of time that it takes the sound to die out in a given environment.

"Concepts" written by Dr. Hubert Howe, Queens College, New York for CBS Musical Instruments, Educational Research Department, 1300 E. Valencia, Fullerton, California 92631.

Copyright 1969

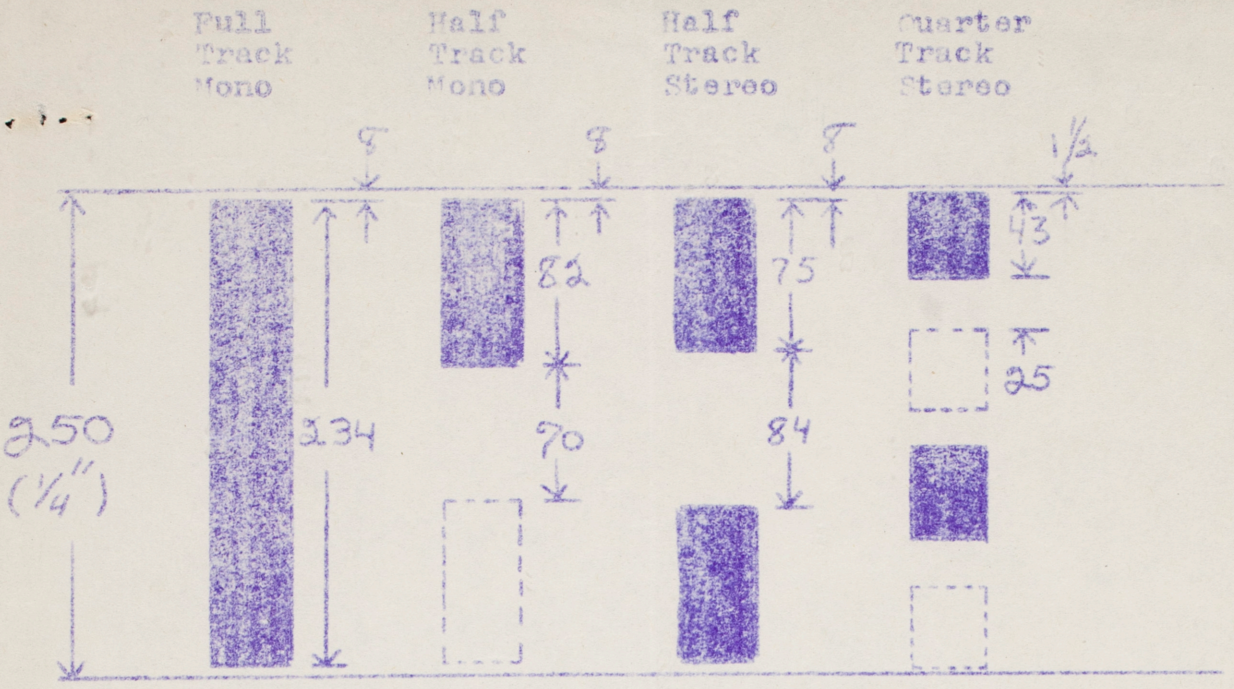

Full Track Mono
Half Track Mono
Half Track Stereo
Quarter Track Stereo
8
8
8
1½
250 (¼")
234
82
70
75
84
43
25

Figure One

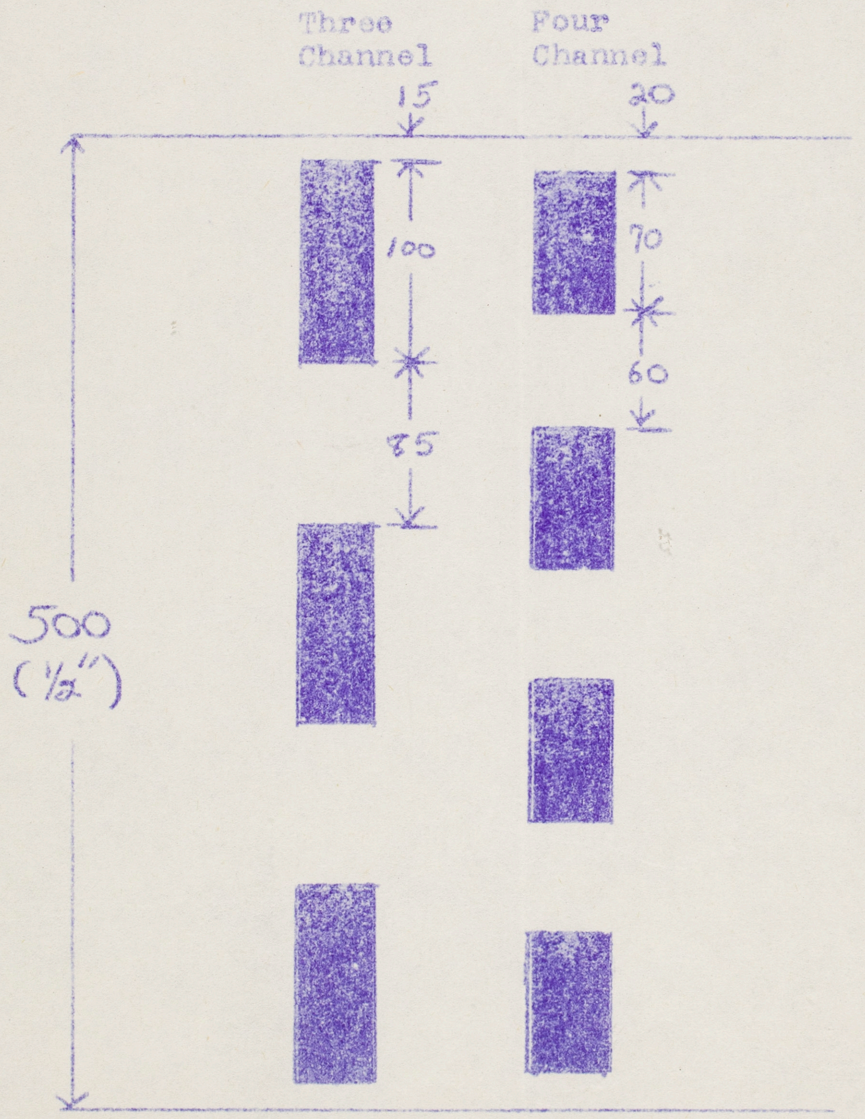
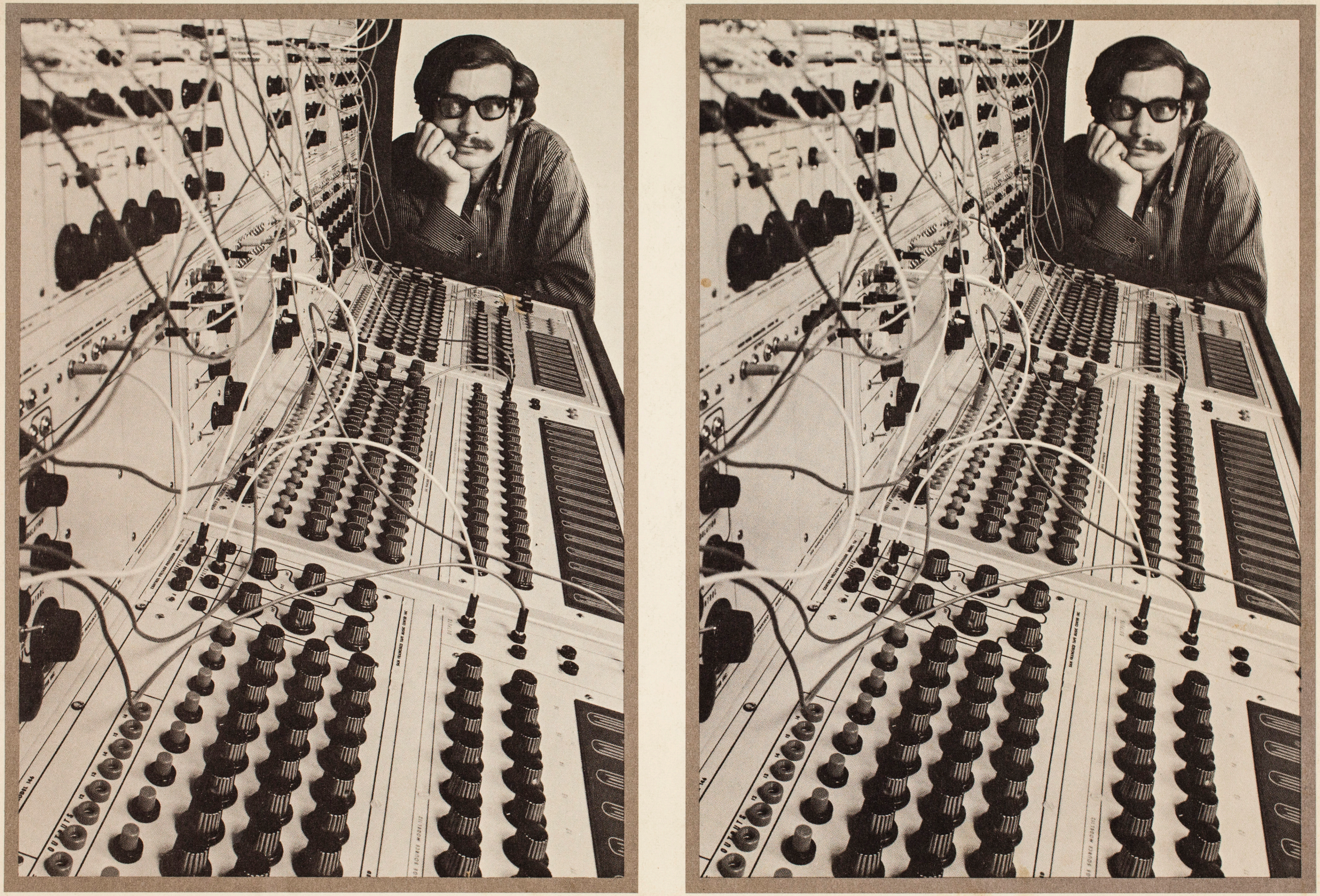

Three Channel
Four Channel
15
20
500 (½")
100
85
70
60

Figure Two

floor rattler
woofer
tweeter



The Buchla Box

New music via electronics.

CBS Musical Instruments offer a vastly improved instrument for composition of electronic music. It produces a widely varied vocabulary of sounds in any combination of time signatures and tempos, and explores new realms of tonality and structure.

The Buchla Box is a modular electronic system designed to facilitate composition of a new kind of music. It is the product of extensive research into the burgeoning field of electronic music composition and application of advanced techniques. The instrument can generate several voices simultaneously, creating a high density of sounds with more voices than can be achieved in general studios.

Modular construction.

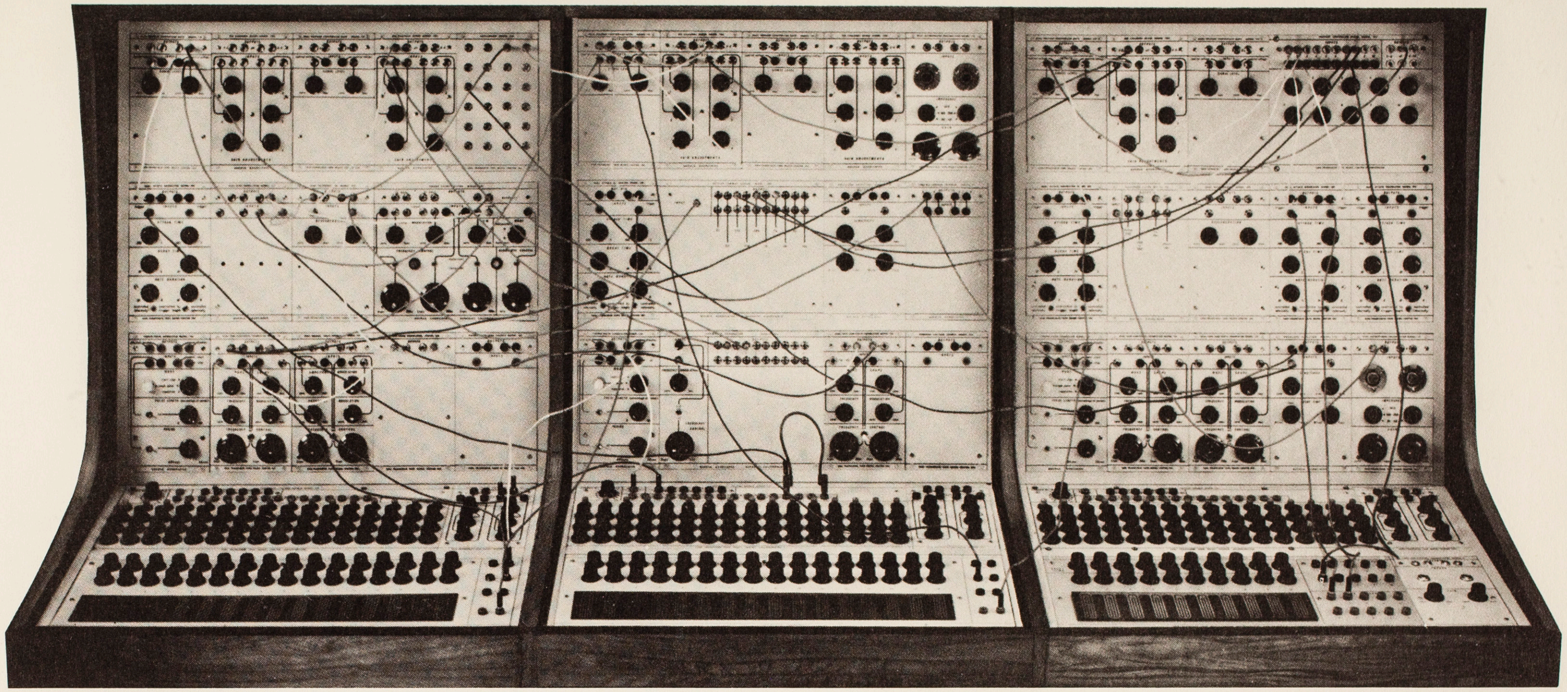
Functional modules, each designed to generate a particular class of signals, or perform a specific type of signal processing, comprise the Box. The system employs three varieties of signals, each with a distinctly different function.

Audio signals, the raw material of electronic music are formed by various sorts of generators (sine, square, sawtooth, harmonic), or are produced externally by tape, loop or radio microphone. In composing a piece, they may be filtered, gated, mixed, modulated, or otherwise processed. Patch cords carrying audio signals within the system are grey shielded cables terminated with miniature phone plugs. A standard level of 0 db. (ref. 600Ω) is used for audio signals within the system.

Control voltage, used to determine frequencies, envelope characteristics, amplitudes and other parameters, are generated by keyboards, programmable voltage sources, and format generators. Black banana plug patch cords are used to interconnect control voltages. The standard control voltage range is from .5 to 15 volts.

Timing pulses are originated by keyboards, touch-activated keyboards, programmable sequencers, and pulse generators. They are used to trigger notes, open gates, or initiate chains of musical events. Timing losses are about 10 volts in amplitude and are interconnected with red banana plug patch cords.

The rules for interconnection are straightforward. Any number of inputs may be connected to a single output. Timing pulse outputs may be paralleled and connected to one input. The system output may be derived from any module. Output is of sufficient magnitude to drive line inputs on tape recorders or sensitive inputs on power amplifiers.



A new art form

Electronic music now has developed into an advanced musical form that includes concert pieces, film music, TV and radio commercial backgrounds, rock and roll, and jazz. Sound studios, night clubs, stages and theaters are incorporating electronic music systems into their recording and amplifying set ups. An increasing number of composers such as Morton Subotnick are already active in the field of electronic composition. Shortly, electronic music may be a part of the curriculum at every college and university music department.

The Buchla Box is designed to be adaptable to all of these uses. It has achieved basic objectives intrinsic in producing an improved line of studio equipment.

Direct, immediate control of musical parameters. The Buchla Box plays in real time without setting frequencies, cutting, measuring and over-dubbing. Tape-splicing is reduced or eliminated by provisions for programming a series of sounds or sound events and playing the series in a desired sequence.

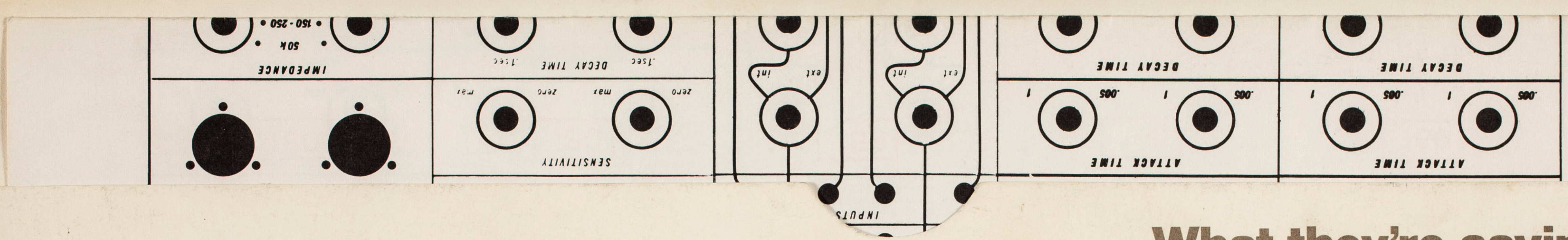
1. All equipment is compatible. Rules for interconnecting are simple and consistent. Interfacing external equipment (recorders, tuners, microphones, etc.) is readily accomplished.

2. Fully transistorized circuitry, conservative design and high quality components, ensure reliability and minimum maintenance.

3. Lightweight modules provide portability for composer's home, concert hall, studios.

4. Cost is reasonable. Power supplies and cabinetry are common to several units. Modular construction permits economical system expansion.

5. The range of sounds and formats far exceeds that previously available. Adaptability and use facility are superior to any related instruments.


IMPEDANCE
50k
150 - 250
DECAY TIME
.1sec
SENSITIVITY
zero
max
ext
int
INPUTS
DECAY TIME
ATTACK TIME
.005
1
DECAY TIME
ATTACK TIME

What they're saying...

"The instrument is the answer for composers who wish to work with electronic materials but care nothing for electronics, and teachers will find it student-proof."

Robert Erickson,
Composer
Teacher, San Francisco
Conservatory of Music

"Aside from being an imaginatively flexible studio instrument, the Buchla Box is practical for a composer to have a complete electronic music studio in his own home."

Mort Subotnick,
Composer

"...a keyboard connected to an enormous range of the sounds of our time. Every composer should come to see, hear, and possibly play the thing, just to know what resources the Buchla Box has made available."

Lou Gotlieb,
San Francisco Chronicle

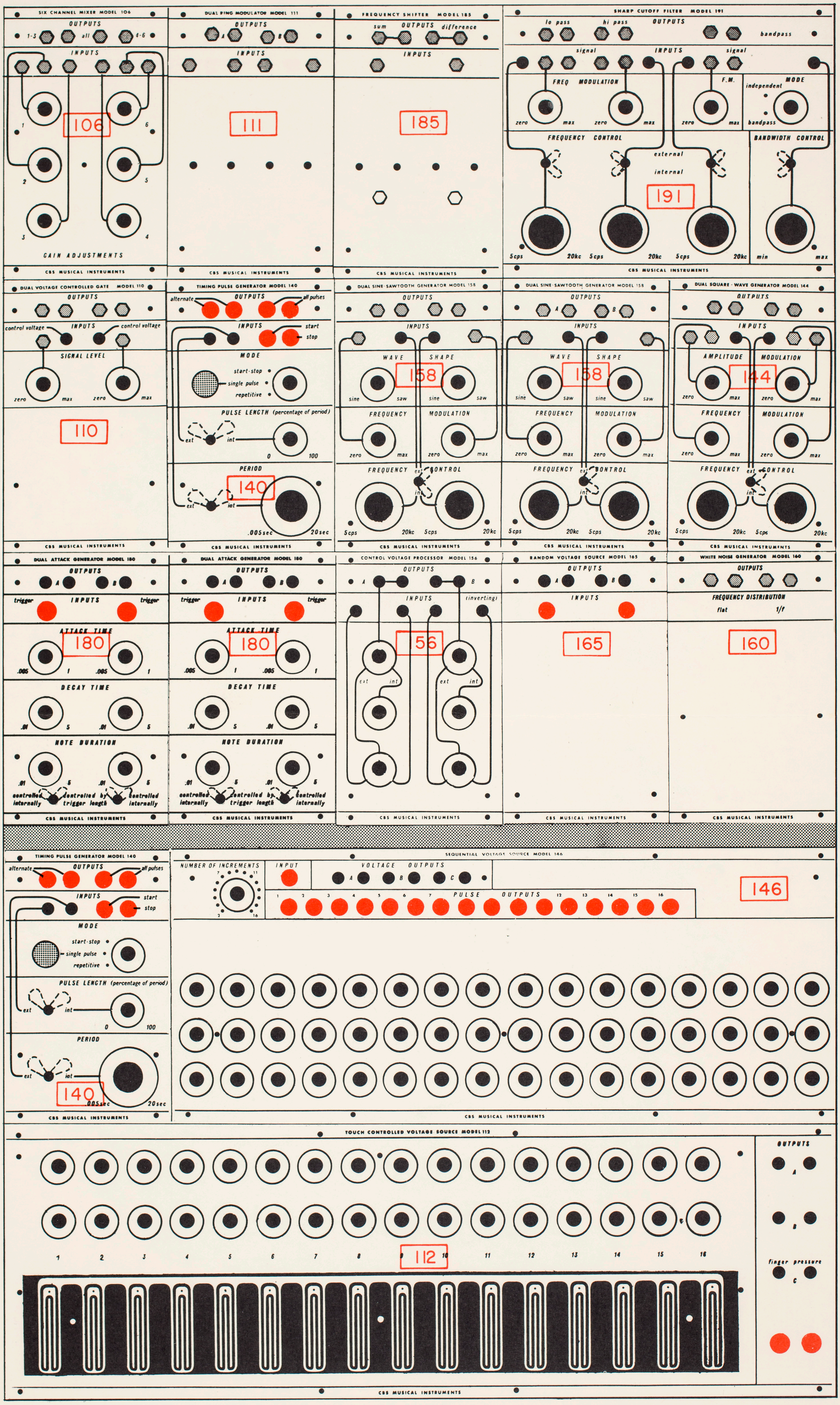
Availability.

The Buchla Electronic Music System is manufactured and sold by CBS Musical Instruments. For full information, delivery and terms, contact: Education Research Department, CBS Musical Instruments, Columbia Broadcasting System, Inc., 1300 E. Valencia St., Fullerton, California 92631.

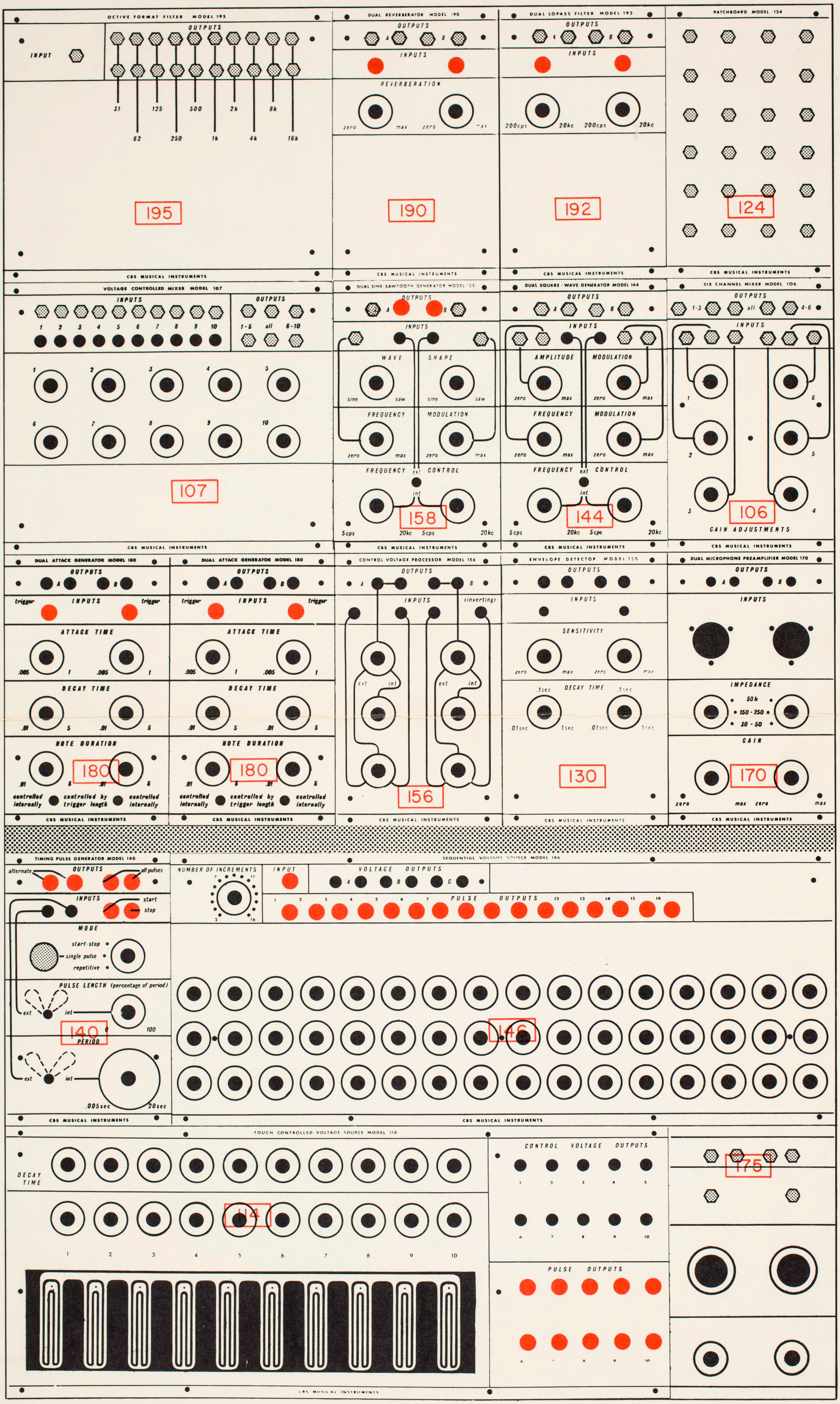
Buchla

Printed in U.S.A.

Buchla Electronic Music System Patch Chart


SIX CHANNEL MIXER MODEL 106
OUTPUTS
1-3
all
4-6
INPUTS
1
2
3
4
5
6
106
GAIN ADJUSTMENTS
CBS MUSICAL INSTRUMENTS
DUAL RING MODULATOR MODEL 111
OUTPUTS
A
B
INPUTS
111
CBS MUSICAL INSTRUMENTS
FREQUENCY SHIFTER MODEL 185
sum
OUTPUTS
difference
INPUTS
185
CBS MUSICAL INSTRUMENTS
SHARP CUTOFF FILTER MODEL 191
lo pass
hi pass
OUTPUTS
bandpass
signal
INPUTS
signal
FREQ MODULATION
F.M.
MODE
independent
bandpass
zero
max
FREQUENCY CONTROL
BANDWIDTH CONTROL
external
internal
191
5cps
20kc
min
max
CBS MUSICAL INSTRUMENTS
DUAL VOLTAGE CONTROLLED GATE MODEL 110
OUTPUTS
control voltage
INPUTS
control voltage
SIGNAL LEVEL
zero
max
110
CBS MUSICAL INSTRUMENTS
TIMING PULSE GENERATOR MODEL 140
alternate
OUTPUTS
all pulses
INPUTS
start
stop
MODE
start-stop
single pulse
repetitive
PULSE LENGTH (percentage of period)
ext
int
0
100
PERIOD
140
.005sec
20sec
CBS MUSICAL INSTRUMENTS
DUAL SINE-SAWTOOTH GENERATOR MODEL 158
OUTPUTS
A
B
INPUTS
WAVE
SHAPE
158
sine
saw
FREQUENCY
MODULATION
zero
max
FREQUENCY
ext
CONTROL
int
5cps
20kc
CBS MUSICAL INSTRUMENTS
DUAL SQUARE-WAVE GENERATOR MODEL 144
OUTPUTS
INPUTS
AMPLITUDE
MODULATION
144
zero
max
FREQUENCY
MODULATION
FREQUENCY
ext
CONTROL
int
5cps
20kc
CBS MUSICAL INSTRUMENTS
DUAL ATTACK GENERATOR MODEL 180
OUTPUTS
A
B
trigger
INPUTS
trigger
ATTACK TIME
180
.005
1
DECAY TIME
.01
5
NOTE DURATION
controlled internally
controlled by trigger length
CBS MUSICAL INSTRUMENTS
CONTROL VOLTAGE PROCESSOR MODEL 156
OUTPUTS
A
B
INPUTS
(inverting)
156
ext
int
CBS MUSICAL INSTRUMENTS
RANDOM VOLTAGE SOURCE MODEL 165
OUTPUTS
A
B
INPUTS
165
CBS MUSICAL INSTRUMENTS
WHITE NOISE GENERATOR MODEL 160
OUTPUTS
FREQUENCY DISTRIBUTION
flat
1/f
160
CBS MUSICAL INSTRUMENTS
TIMING PULSE GENERATOR MODEL 140
alternate
OUTPUTS
all pulses
INPUTS
start
stop
MODE
start-stop
single pulse
repetitive
PULSE LENGTH (percentage of period)
ext
int
0
100
PERIOD
140
.005sec
20sec
CBS MUSICAL INSTRUMENTS
SEQUENTIAL VOLTAGE SOURCE MODEL 146
NUMBER OF INCREMENTS
INPUT
VOLTAGE OUTPUTS
A
B
C
PULSE OUTPUTS
1 2 3 4 5 6 7 12 13 14 15 16
146
CBS MUSICAL INSTRUMENTS
TOUCH CONTROLLED VOLTAGE SOURCE MODEL 112
OUTPUTS
A
B
finger pressure
C
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
112
CBS MUSICAL INSTRUMENTS

Educational Research Department,
CBS Musical Instruments, Columbia
Broadcasting System Inc., 1300 E.
Valencia, Fullerton, California 92631.


OCTIVE FORMAT FILTER MODEL 195
INPUT
OUTPUTS
31 62 125 250 500 1k 2k 4k 8k 16k
195
DUAL REVERBERATOR MODEL 190
OUTPUTS A B
INPUTS
REVERBERATION
zero max zero max
190
DUAL LOPASS FILTER MODEL 192
OUTPUTS A B
INPUTS
200cps 20kc 200cps 20kc
192
PATCHBOARD MODEL 124
124
CBS MUSICAL INSTRUMENTS
VOLTAGE CONTROLLED MIXER MODEL 107
INPUTS
1 2 3 4 5 6 7 8 9 10
OUTPUTS
1-5 all 6-10
107
DUAL SINE-SAWTOOTH GENERATOR MODEL 158
OUTPUTS A B
INPUTS
WAVE
SHAPE
sine saw sine saw
FREQUENCY
MODULATION
zero max zero max
FREQUENCY ext CONTROL int
5cps 20kc 5cps 20kc
158
DUAL SQUARE-WAVE GENERATOR MODEL 144
OUTPUTS A B
INPUTS
AMPLITUDE
MODULATION
FREQUENCY
FREQUENCY ext CONTROL int
5cps 20kc 5cps 20kc
144
SIX CHANNEL MIXER MODEL 106
OUTPUTS 1-3 all 4-6
INPUTS
GAIN ADJUSTMENTS
106
DUAL ATTACK GENERATOR MODEL 180
OUTPUTS A B
trigger INPUTS trigger
ATTACK TIME
.005 1 .005 1
DECAY TIME
.01 5 .01 5
NOTE DURATION
controlled internally
controlled by trigger length
controlled internally
180
CONTROL VOLTAGE PROCESSOR MODEL 156
OUTPUTS A B
INPUTS (inverting)
ext int ext int
156
ENVELOPE DETECTOR MODEL 130
OUTPUTS
INPUTS
SENSITIVITY
zero max zero max
DECAY TIME
.01sec .1sec 1sec
130
DUAL MICROPHONE PREAMPLIFIER MODEL 170
OUTPUTS A B
INPUTS
IMPEDANCE
50k
150-250
30-50
GAIN
zero max zero max
170
TIMING PULSE GENERATOR MODEL 140
alternate OUTPUTS all pulses
INPUTS start stop
MODE
start-stop
single pulse
repetitive
PULSE LENGTH (percentage of period)
ext int
0 100
PERIOD
ext int
.005sec 20sec
140
SEQUENTIAL VOLTAGE SOURCE MODEL 146
NUMBER OF INCREMENTS
INPUT
VOLTAGE OUTPUTS A B C
PULSE OUTPUTS
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
146
TOUCH CONTROLLED VOLTAGE SOURCE MODEL 114
DECAY TIME
1 2 3 4 5 6 7 8 9 10
CONTROL VOLTAGE OUTPUTS
PULSE OUTPUTS
114
175
CBS MUSICAL INSTRUMENTS